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THE FIFTH ESTATE

Science (October 3, 1924) published an address on "The Fifth Estate" delivered by Dr. Arthur D. Little, a chemical engineer in Boston, at the centenary celebration of the founding of the Franklin Institute and the inauguration of the Bartol Research Foundation.

There is so much worth chewing and digesting in this address that some extracts are given here.

Doctor Little accounts for his subject thus: In the days when the church and the nobility made the laws, these groups formed the First and Second Estates; when the common people secured a part in legislation, they were called the Third Estate. Then one day, Edmund Burke, during a speech in Parliament pointing to the Reporters' Gallery, said, "There sits a Fourth Estate more important far than they all." Since that day the press has claimed this distinction:

This Fifth Estate, to which your attention is appropriately invited on the centenary of the Franklin Institute, is composed of those having the simplicity to wonder, the ability to question, the power to generalize, the capacity to apply. It is, in short, the company of thinkers, workers, expounders, and practitioners upon which the world is absolutely dependent for the preservation and advancement of that organized knowledge which we call science. It is their seeing eye that discloses, as Carlyle said, "the inner harmony of things; what Nature meant." It is they who bring the power and the fruits of knowledge to the multitude who are content to go through life without thinking and without questioning, who accept fire and the hatching of an egg, the attraction of a feather by a bit of amber, and the stars in their courses as a fish accepts the ocean. * * *

Although the brotherhood of the Estate is open to all the world, its effective membership nowhere comprises more than an insignificant proportion of the population. * * * One may hazard the estimate that there are not in all the world 100,000 persons whose creative effort is responsible for the advancement of science. * * * Seventy-five per cent are dependent upon the universities for support, from which we may assume that the burden of the higher surtaxes does not bear heavily upon the Fifth Estate. * * *

Initiative is one of the rarest mental qualities, yet without it progress is impossible. Its combination with the scientific imagination and command of fact is still rarer and more precious. Since comparatively few of those who study science develop the capacity to extend its borders the cost of a man competent to advance science has been estimated at $500,000 and his value to the community set at a far greater figure. Full membership in the Fifth Estate thus seems to invoive the highest initiation fee on record. It is a figure disconcerting to the candidate but as Wiggam has finely said: "Only genius can create science, but the humblest man can be taught its spirit." He can learn to face truth.

Doctor Little gives as one reason that the Fifth Estate is not better appreciated, their "preposterous and terrifying language" which they have evolved in their endeavors to secure accuracy in definition and expression. "If knowledge is to be humanized it must first be translated." Also, "It should be the object of all education to produce the scientific attitude toward truth."

Now vision, a trained intelligence and an open mind are the qualities which characterize all those who are worthy of membership in the Fifth Estate. They are qualities which the many-sided Franklin possessed in exceptionally high degree.

The "many-sided Franklin," Doctor Little says,

Had not enough buttons on his black coat to tell off the multifarious aspects in which his complex personality was presented to the world. He was craftsman and tradesman; philosopher and publicist; diplomat, statesman and patriot. And he was, withal, a very human being. What concerns us particularly on this occasion is the fact that he was at once philosopher and man of affairs. His remarkable career should refute forever the fallacy, which, unfortunately, still is current, that the man of science is temperamentally unfitted for the practical business of life.

Among all the activities with which his busy life was crowded Franklin undoubtedly found his greatest pleasure in the pursuit of science, and in that pursuit he followed the eclectic method. At a time when nearly everything awaited explanation his focussed attention ranged like a search-light over many fields. He observed the movement of winds and developed a theory of storms. He considered ventilation and the causes of smoky chimneys and proceeded to invent new stoves. He introduced the Gulf Stream to Falmouth skippers and demonstrated the calming effect of oil on turbulent seas to officers of the British Navy at Portsmouth. From earthquakes he turned to the heat absorption of colored cloths and the fertilizing properties of gypsum. He wrote on sun spots and meteors, waterspouts, tides and sound. The kite, which for centuries had been the toy of boys, became in Franklin's hands a scientific instrument, the means to a great discovery. That its significance is, even now, not universally appreciated is shown by the recent answer of a school-boy, "Lightning differs from electricity because you don't have to pay for lightning." To Franklin, as the child of every man knows, we owe our initial conceptions of positive and negative electricity and he was the first to suggest that the aurora is an electrical phenomenon. * * *

Benjamin Franklin died in 1790—one hundred and thirty-four years ago. Could he return to make appraisal what wonders would confront his astonished vision, what triumphs of the Fifth Estate compel his admiration.

Electricity, which to his contemporaries was little more than an obscure force, the curious manifestations of which might supply an evening's entertainment, has become the structural basis of the universe. The atom of Democritus is now a microcosm, vibrant with energy that glows in the white light of the electric lamps, which have replaced the tallow dip. In place of the electrophorus and the charges of the Leyden jar he would find in our own country alone twenty-seven million horsepower driving generators in thousands of stations from which electric energy is distributed to our homes and factories and transportation lines to perform innumerable services. Imagine, if you can, the stunning impact of the impressions that would crowd the day of his return.

The address succinctly and eloquently recounts some of the transcendental changes in the life of man in the past century. Then follows the question:

With contributions to their credit which have so enriched and stimulated the intellectual life; which have brought the peoples of the earth together into closer touch than English shires once were; which have revolutionized industry, enlarged the opportunity of the average man, and added so greatly to his comfort and well-being, we may reasonably inquire, What are the recompenses of the Fifth Estate?

On the material side they have almost invariably been curiously inadequate and meager. It is incomparably more profitable to draw the Gumps for a comic supplement than to write "The Origin of Species." There is more money in chewing gum than in relativity. Lobsters and limousines are acquired far more rapidly by a skillful thrower of custard pies in a moving-picture studio than by the no less skillful demonstrator of the projection of electrons. The gate receipts of an international prize fight would support a university faculty for a year.

One may recall that Lavoisier was guillotined by a republic that "had no need of chemists," that Priestley was driven from his sacked and devastated home, that Leblanc, after giving the world cheap alkali, died in a French poorhouse, that Langley was crushed by ridicule and chagrin in his last days. A month before the war who could have believed that within a few years the Fifth Estate in Russia would be utterly destroyed and in Germany and Austria existing at the very edge of starvation. What has happened there may happen again elsewhere if the intelligence of the world does not assume and hold its proper place in the direction of national and world affairs. * * *

The professional spirit which animates the Fifth Estate is essentially one of service. Its compelling urge in the search for truth springs from the conviction that the Truth shall make men free. * * *

Franklin was a man of science, but his career proclaims that it is possible to be a man of science and much more besides. Science was made for life and life is more than science. Art in its fullest expression may touch deeper springs, human relations and affections may bring richer rewards, and public affairs may make a more imperious claim. With Franklin as their prototype the members of the Fifth Estate may well strive to emulate his devotion to the public service and his broad and constructive interest in human problems and affairs.

Error and misconception have a feline tenacity of hold upon life, and the Fifth Estate, though richly endowed with latent executive capacity, is still in popular opinion regarded as equipped for thought rather than for action. The practical man, busily engaged in repeating the errors of his forefathers, has little time and less consideration for the distracting theories and disconcerting facts of the man of science. Yet who, among the men of action, is more intensely and truly practical than Carty, Baekeland, Reese or Whitaker? Where shall one find a firmer grasp on the details of business than that possessed by E. W. Rice, Jr., Gerard Swope or Dr. Nichols? What quality caused the young director of a research laboratory to find himself responsible for the production of gas masks to protect four million fighting men? In a time of dire emergency it was a professor of chemistry who organized the great Edgewood Arsenal and developed the means and methods and the trained personnel required to supply munitions for a new type of warfare. It was not to a statesman or a business man or a great manufacturer that the Allies entrusted the supreme command. It was to a teacher in a French Military school. The range and value of their public service obscures the fact that Charles W. Eliot was a professor of chemistry and that Hoover is an engineer. The League of Nations is the child of a schoolmaster.

Of the influence of the Fifth Estate in politics Doctor Little said:

Numerically the Fifth Estate has always been feeble and insignificant. Its total membership at any time could be housed comfortably in a third-rate city. No politician makes a promise or invents a phrase to attract its scattered and ineffective vote. Rarely do its members sit in Congress: when they do they sit in the gallery.

With less political influence than the sparse population of Nevada the Fifth Estate has recast civilization through its study and application of "the great and fundamental facts of Nature and the laws of her operation." * * *

Science has so drawn the world together and so rapidly remoulded civilization that the social structure is now strained at many points. Statecraft and politics, law and custom lack the plasticity of science and are now in imperfect contact with the contours of their new environment. The result, as events have shown, is friction and confusion. Though our civilization is based on science, the scientific method has little place in the making of our laws. Office does not seek the man in the laboratory, and candidates are not pictured as engaged in any activity that might suggest a superior intelligence. * * *

It is claimed that fifty per cent of the members of state legislatures in America have never been through high school and that only one in seven has been through college. We see in the ranks of science knowledge without power and in politics power without knowledge. An electorate, which regards itself as free, listens to the broadcasted noise of manufactured demonstrations and is blind to the obvious mechanics of synthetic bedlam. The result is too often government by gullibility, propaganda, catch-words and slogans, instead of government by law based on facts principles, intelligence and good will. * * *

The world is wrong because few men can think. It will not be made right until those who can not think trust those who can. When its foundations are so obviously out of joint humanity still clings tenaciously to fossilized precepts and opinions and is as resentful of suggested changes as in the days of Galileo. Despite the pressure of new ideas, education must still, to be acceptable, follow old conventional lines. * * *

To those who would have us believe that all wealth is produced by labor the Fifth Estate replies, "Wealth is the product of brains, and labor is productive only as it is guided by intelligence."

Science is the great emancipator of labor. Bagehot has somewhere said, perhaps in "Physics and Politics," that, during the early stages of civilization slavery was essential to progress because only through the enforced labor of the many could the few have leisure to think. Today, in the United States, the supply of available energy is equivalent to sixty man power for every man, woman, and child. There is now leisure for all to think, but the millions prefer the movies.

It is not labor but the trained intelligence of the Fifth Estate which has endowed man with his present control of stupendous forces. It has solved problems that for ages have hindered and beset mankind. It has revealed great stores of raw materials, synthesized scores of thousands of new compounds, furnished the fundamental data which find embodiment in machines and processes and in those agencies of transportation and communication that have made of the world a neighborhood. It has enabled man effectively to combat diseases, added years to the average life, and made it better worth the living.

Not "so little done, so much to do," but "so much done, so much to do" is the theme of the closing paragraphs of the address:

Human life is still a hard and fearsome thing. We are everywhere overburdened by unnecessary illness, crushing taxation, extravagant and inefficient governments, huge expenditures for trivialities and the appalling waste of effort, material and resources. We are hampered by class suspicion and misunderstanding, racial antagonisms, the inhibitions of organized labor and the lack of imagination in high places. Life in general is on a low cultural plane and bound by custom and tradition.

One hundred years of science have failed to satisfy one craving of humanity. * * *

Thus we still encourage race-deterioration, still carry the burden of the unfit, still cultivate national antipathies, still are breeding from poor stock, and witnessing with equanimity the suppression of the best.

The history of aristocracies, feudalism, the church, the guilds and the soviets has amply demonstrated that no one class possesses the qualities required for the government of all classes, and we can not claim them for the Fifth Estate. We can, however, claim with full assurance that the Fifth Estate possesses many qualities, now practically ignored, which could be utilized in government to the incalculable advantage of us all. Its knowledge of material facts, of natural and economic laws, of the factors governing race development and human relations; its imagination, vision, and its open mind should be brought to bear effectively in the formulation of national policies and the solution of governmental problems. * * *

Plato called democracy "the best form of bad government." It will be the best form of good government only as it develops the capacity to breed leaders and the faith to trust them. The quality of our children will determine the quality of our democracy. If our laws and mores and economic structure, continue to discourage breeding from our best strains, if there is to be no adequate recompense for service of the higher types, the time is not far distant when democracy will no longer be safe for the world. If the Fifth Estate were everywhere to be wiped out, as it has been in Russia, the result would be vastly more calamitous than universal war. * * *

Our civilization is certainly imperiled, but there will be no downfall if mankind can be taught to follow the light already before it. As lantern bearers, it is the clear duty of the Fifth Estate to show the way. In the past the world has suffered grievously from lack of knowledge; today it suffers from its rejection or misapplication. Could the springs of human conduct and the affairs of peoples now be regulated only as wisely as we now know how there would be work and leisure and decent living for all. The criminal, the defective, the feeble-minded would be breeded out, and sane minds in sound bodies breeded in. The loss and suffering from preventable disease and accident would not be tolerated. Higher standards would govern the selection for the public service. Planning would replace *laissez-faire* development, and a rational conservation check the

reckless waste of our resources. Production and distribution would attain to levels of efficiency altogether new, and the many injustices now existent in human relations would wellnigh disappear. With the reaction of a freed intelligence on politics, religion, morals we might hope for a broader tolerance, a better mutual understanding. * * *

We might reasonably expect ugliness to be replaced by beauty in our cities and small towns and later even in our homes. Government by intelligence for the general good of all should supersede government by special interests, blocs, faddists and fear of organized minorities and the uninformed crowd. With it all would come relief from the economic pressure, which bears so heavily upon the Fifth Estate that its children, which should be counted among the best assets of the community, are now a luxury.

The world needs most a new tolerance, a new understanding, an appreciation of the knowledge now at hand. For these it can look nowhere with such confidence as to the members of the Fifth Estate. Let us, therefore, recognize the obligation we are under. Ours is the duty and the privilege of bringing home to every man the wonders, the significance, and the underlying harmony of the world in which we live.

THE NORMAL JUICE FACTOR: ITS POSSIBILITIES AS A BASIC CONTROL FACTOR IN THE CHEMICAL CONTROL OF CANE SUGAR FACTORIES

By Arnold H. Warren

Chemist, San Carlos Milling Co., Ltd.[1]

INTRODUCTION

Definition of Normal Juice Factor.—The *normal juice factor* is defined as follows:

$$\text{Normal juice factor} = 100 \times \frac{\text{Brix of normal juice}}{\text{Brix of crusher (first expressed) juice}}$$

The normal (or absolute) juice is defined as the whole juice of the cane; that is, everything in the cane except the fiber. The cane may, therefore, be considered as composed of two parts—normal juice and fiber.

The use of a constant in the determination of variables.—It is a well known mathematical principle that if the relation which obtains between two or more variables can be expressed as a constant, that constant may be utilized to express the value of any one of the variables in terms of the others. And if the value of any one of the variables be unknown, its value can be calculated by means of the constant from the known values of the other variables involved. The Java Ratio represents a familiar application of this mathematical principle to calculations involved in the chemical control of cane sugar factories.

The value of such a factor as the Java Ratio is in inverse proportion to its variability, that is, the more nearly constant it is, the greater its utility. Although the Java Ratio, for lack of a better factor, has found a very wide application, its utility will always be limited by the fact that it varies within comparatively wide limits.

Possibilities for more extended use of the normal juice factor.—The full possibilities of the so-called *normal juice factor* as a means of maintaining close chemical control in cane sugar factories have not, I am sure, been fully realized. It has been known for some years that the *normal juice factor* varies within extremely narrow limits and is, in fact, almost constant. Unfortunately, however, the relationship between this constant and a number of important variable factors involved in the control of cane sugar factories (the percentage of fiber in cane and the weight of the mixed juice, for example) has not been recognized. As a result, the *normal juice factor* has been considered of very minor importance and the only use made of it in most factories has been as a means of approximating the Brix of the normal juice from the crusher juice for the purpose of calculating dilution.

The purpose of this article is to show that the *normal juice factor* may be utilized to express a constant relationship between a number of important variables with which it has not hitherto been associated, and that because of this

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[1] San Carlos, Occidental Negros, P. I.

constant relationship the *normal juice factor* may become a basic control factor of cardinal importance in the chemical control of cane sugar factories.

DETERMINATION OF BRIX OF NORMAL JUICE

Direct method.—The practical application of the *normal juice factor* to laboratory control depends upon the determination accurately for any given period of the actual average Brix of the normal juice. And this is obviously not possible by direct analysis. Quoting from page 37 of "Methods of Chemical Control" (Hawaiian Chemists' Association, 1916), "the Brix of the normal juice is found by averaging the Brix of the juice from the different sets of rollers and from the bagasse when no water is used on the mills." Since in actual milling practice water is used on the mills, a direct determination of the Brix of the normal juice is possible only on those rare occasions when dry milling tests are made.

Indirect method.—This practical difficulty has, no doubt, prevented the general recognition of the possibilities of the *normal juice factor* as a basic factor in chemical control. The writer has overcome this difficulty be developing the following indirect method of calculating the Brix of the normal juice.

Let Bn = Brix of normal juice
Bm = Brix of mixed juice
Bb = Percentage of soluble solids in bagasse
Fc = Percentage of fiber in cane
Fb = Percentage of fiber in bagasse
Wm = Weight of mixed juice
Wc = Weight of cane

Then $100 - Fc$ = Normal (or absolute) juice percentage of cane

$\frac{Wm}{Wc}$ = Mixed juice percentage of cane (expressed as a decimal)

$\frac{Fc}{Fb}$ = Bagasse percentage of cane (expressed as a decimal)

$Bm\left(\frac{Wm}{Wc}\right)$ = Soluble solids in mixed juice percentage of cane

$Bb\left(\frac{Fc}{Fb}\right)$ = Soluble solids in bagasse percentage of cane

$Bm\left(\frac{Wm}{Wc}\right) + Bb\left(\frac{Fc}{Fb}\right)$ = Total soluble solids percentage of cane

$$(1)\quad \text{Whence } Bn = 100\left[\frac{Bm\left(\frac{Wm}{Wc}\right) + Bb\left(\frac{Fc}{Fb}\right)}{100-Fc}\right]$$

GENERAL FORMULA FOR THE NORMAL JUICE FACTOR IN TERMS OF THE VARIABLES INVOLVED

Let N = Normal juice factor
Let Bc = Brix of crusher (or first expressed) juice

Then, by definition: $N = 100\left(\frac{Bn}{Bc}\right)$

Whence, substituting for Bn its value as given by (1) above:

$$(2)\quad N = 100\left\{\frac{100\,\dfrac{Bm\left(\dfrac{Wm}{Wc}\right)+Bb\left(\dfrac{Fc}{Fb}\right)}{100-Fc}}{Bc}\right\}$$

This formula (2) expresses the *normal juice factor* in terms of the seven variables involved. As each of these seven variables is regularly determined as a part of the ordinary laboratory routine, it is a simple matter to calculate the value of the *normal juice factor* by substitution in the above formula of the values for any given period of the seven variables involved.

SUBSIDIARY FORMULAS DERIVED FROM THE GENERAL FORMULA FOR THE NORMAL JUICE FACTOR

Since the value of N is very nearly constant, an average value may be assumed for N and any *one* of the variables involved which may be unknown calculated accordingly.

The following formulas express successively the value of each one of the seven variables in terms of the other six and the *normal juice factor*. These formulas are derived from the general formula (2) for the *normal juice factor* by simple algebraic transposition.

(3) Percentage of fiber in cane:

$$Fc = 100\left[\frac{Bc\left(\dfrac{N}{100}\right)-Bm\left(\dfrac{Wm}{Wc}\right)}{Bc\,\dfrac{\dfrac{N}{100}}{100}+\dfrac{Bb}{Fb}}\right]$$

(4) Weight of cane:

$$Wc = \frac{Bm \cdot Wm}{\left(\dfrac{N}{100}\right)\left(\dfrac{Bc}{100}\right)(100-Fc)-Bl\left(\dfrac{Fc}{Fb}\right)}$$

(5) Weight of mixed juice:

$$Wm = \frac{Wc\left[\left(\dfrac{N}{100}\right)\left(\dfrac{Bc}{100}\right)(100-Fc)-Bb\left(\dfrac{Fc}{Fb}\right)\right]}{Bm}$$

(6) Brix of mixed juice:

$$Bm = \frac{Wc\left[\left(\dfrac{N}{100}\right)\left(\dfrac{Bc}{100}\right)(100-Fc)-Bb\left(\dfrac{Fc}{Fb}\right)\right]}{Wm}$$

(7) Brix of crusher (1st Exp.) juice:

$$Bc = 100\left[\frac{Bm\left(\dfrac{Wm}{Wc}\right)+Bb\left(\dfrac{Fc}{Fb}\right)}{\left(\dfrac{N}{100}\right)(100-Fc)}\right]$$

(8) Percentage of fiber in bagasse: $$Fb = \frac{Fc \cdot Bb}{\left(\frac{N}{100}\right)\left(\frac{Bc}{100}\right)\left(100 - Fc\right) - Bm\left(\frac{Wm}{Wc}\right)}$$

(9) Percentage of soluble solids in bagasse: $$Bb = \frac{Fb\left[\left(\frac{N}{100}\right)\left(\frac{Bc}{100}\right)\left(100 - Fc\right) - Bm\left(\frac{Wm}{Wc}\right)\right]}{Fc}$$

ADDITIONAL VARIABLES INVOLVED IN DETERMINATION OF PERCENTAGE OF SOLUBLE SOLIDS IN BAGASSE (Bb)

In the statement of the general formula for the *normal juice factor*, the percentage of soluble solids in bagasse (*Bb*) has been considered as a single variable. The percentage of soluble solids in bagasse is, however, always calculated indirectly from two other variables which are themselves determined by direct analysis. By direct analysis is obtained:

Jl = Purity of last expressed juice.
Pb = Percentage of polarization in bagasse.
Let Bb = Percentage of soluble solids in bagasse.

(10) Then $$Bb = 100\left(\frac{Pb}{Jl}\right)$$

ADDITIONAL VARIABLES INVOLVED IN DETERMINATION OF PERCENTAGE OF FIBER IN BAGASSE (Fb)

In the statement of the general formula for the *normal juice factor*, the percentage of fiber in bagasse (*Fb*) has been considered as a single variable. As a matter of fact, however, the percentage of fiber in bagasse is always obtained indirectly by involving three other variables, which are themselves determined by direct analysis. The familiar formula for obtaining the percentage of fiber in bagasse may be expressed as follows:

Let Jl = Purity of last expressed juice
Pb = Percentage of polarization in bagasse
Mb = Percentage of moisture in bagasse
Fb = Percentage of fiber in bagasse

(11) Then $$Fb = 100 - \left[Mb + 100\left(\frac{Pb}{Jl}\right)\right]$$

ADDITIONAL VARIABLES INVOLVED IN THE INDIRECT DETERMINATION OF PERCENTAGE OF FIBER IN CANE (Fc)

In the statement of the general formula for the *normal juice factor*, the percentage of fiber in cane (*Fc*) has also been considered as a single variable. This is precisely true only when the percentage of fiber in cane is determined by direct

analysis. When the percentage of fiber in cane is determined indirectly, it is a calculation involving a number of other variables which are themselves determined by direct analysis or direct measurement. By direct analysis or direct measurement is obtained:

Jl = Purity of last expressed juice
Pb = Percentage of polarization in bagasse
Mb = Percentage of moisture in bagasse
Ww = Weight of maceration water
Wc = Weight of cane
Wm = Weight of mixed juice
Let Fc = Percentage of fiber in cane

$$(12)\quad \text{Then } Fc = \left[100 - Mb - 100\left(\frac{Pb}{Jl}\right)\right]\left[\frac{Ww + Wc - Wm}{Wc}\right]$$

It will be noted that the first member in brackets represents the percentage of fiber in bagasse as given by formula (11).

LIST OF ALL THE VARIABLES INVOLVED IN THE GENERAL FORMULA FOR THE NORMAL JUICE FACTOR

CASE A: WHEN THE PERCENTAGE OF FIBER IN CANE IS DETERMINED INDIRECTLY

Ww = Weight of maceration water
Wc = Weight of cane
Wm = Weight of mixed juice
Bm = Brix of mixed juice
Bc = Brix of crusher juice
Jl = Purity of last expressed juice
Pb = Percentage of polarization in bagasse
Mb = Percentage of moisture in bagasse

Expressed in terms of these variables:

$$(13)\quad N = \frac{Bm\left(\frac{Wm}{Wc}\right) + 100\left(\frac{Pb}{Jl}\right)\left(\frac{Wc + Ww - Wm}{Wc}\right)}{\left(\frac{Bc}{100}\right)\left[1 - \left(1 - \frac{Mb}{100} - \frac{Pb}{Jl}\right)\left(\frac{Wc + Ww - Wm}{Wc}\right)\right]}$$

CASE B: WHEN THE PERCENTAGE OF FIBER IN CANE IS DETERMINED BY DIRECT ANALYSIS

Fc = Percentage of fiber in cane
Wc = Weight of cane
Wm = Weight of mixed juice
Bm = Brix of mixed juice
Bc = Brix of crusher juice
Jl = Purity of last expressed juice
Pb = Percentage of polarization in bagasse
Mb = Percentage of moisture in bagasse

Expressed in terms of these variables:

$$(14)\quad N = \frac{Bm\left(\frac{Wm}{Wc}\right) + \left(\frac{100Pb}{Jl}\right)\left(\frac{Fc}{100 - Mb - \frac{100Pb}{Jl}}\right)}{\left(\frac{Bc}{100}\right)\left(\frac{100 - Fc}{100}\right)}$$

A LOGICAL FORMULA FOR CALCULATING DILUTION PERCENTAGE OF NORMAL JUICE

Incidentally, it may be observed that from the indirect method herein given for calculating the Brix of the normal juice may be derived a logical formula for calculating the dilution of mixed juice percentage of normal juice. Hitherto, the method in general has been to assume a *normal juice factor*, say 97.5. Then the formula for the dilution percentage of normal juice would be:

$$\text{Dilution percentage of normal juice} = \frac{97.5 \times \text{Brix of crusher juice}}{\text{Brix of mixed juice}} - 100$$

It will be observed that while this formula approximates the actual dilution percentage of normal juice, it is exactly true only for those cases in which the actual value of the *normal juice factor* coincides exactly with the assumed value used in calculating the dilution. A logical formula for calculating the dilution percentage of normal juice is obtained as follows:

Let D = Dilution percentage of normal juice
Bn = Brix of normal juice
Bm = Brix of mixed juice

$$\text{(15) Then } D = 100\left(\frac{Bn}{Bm}\right) - 100$$

Where by formula (1):

$$Bn = 100\left[\frac{Bm\left(\frac{Wm}{Wc}\right) + Bb\left(\frac{Fc}{Fb}\right)}{100 - Fc}\right]$$

Where the value of *Bn* is calculated as a preliminary to obtaining the *normal juice factor*, it is a simple matter to substitute its value in formula (15) above to obtain the exact dilution percentage of normal juice.

EFFECT OF ERRORS IN DETERMINATION OF THE VARIABLES UPON THE NORMAL JUICE FACTOR

The value of the *normal juice factor* in laboratory control lies in the fact that an error in the determination of any of the variables involved is reflected in an abnormal variation of the *normal juice factor* from its average value. The precise effect upon the *normal juice factor* of errors in the determination of the variables depends upon whether the percentage of fiber in cane is determined indirectly or by direct analysis. These two cases are, therefore, considered separately.

CASE A: WHEN THE PERCENTAGE OF FIBER IN CANE IS DETERMINED INDIRECTLY

The actual values of the variables involved in the general formula (13) for the *normal juice factor* are taken as follows:

Weight of maceration water	Ww	=	73.4 tons
Weight of cane	Wc	=	155.7 tons
Weight of mixed juice	Wm	=	192.8 tons
Brix of mixed juice	Bm	=	14.83
Brix of crusher juice	Bc	=	22.29
Purity of last expressed juice	Jl	=	74.39
Percentage of polarization in bagasse	Pb	=	2.18
Percentage of moisture in bagasse	Mb	=	43.50

Now, in order to observe the effect upon the *normal juice factor* of errors in determining the variables, let the value of each one of the variables be varied in turn while all the other variables remain constant at their actual values as given above. And let the *normal juice factor* be calculated in turn for three different values of each variable, its actual value as given above, 99 per cent of its actual value, and 101 per cent of its actual value.

Effect of errors in determining weight of maceration water upon the normal juice factor.—The actual weight of the maceration water is 73.4 tons. But let the *normal juice factor* be calculated separately for:

$$Ww = \begin{cases} (a) & 72.666 \text{ tons} & (99 \text{ per cent of the actual weight}) \\ (b) & 73.400 \text{ tons} & (\text{the actual weight}) \\ (c) & 74.134 \text{ tons} & (101 \text{ per cent of the actual weight}) \end{cases}$$

Let the other variables involved remain constant at their actual values.

The normal juice factor is found to vary with the value chosen for the weight of maceration water as follows:

	(*a*)	(*b*)	(*c*)
Value chosen for weight of maceration water percentage of actual weight	99.0	100.0	101.0
Value obtained for normal juice factor	97.29	97.65	98.00

These results may be summarized as follows:

a. If the value chosen for the weight of the maceration water is too low, the *normal juice factor* will also be too low; and if the value chosen is too high, the *normal juice factor* will also be too high.

b An error of 1.0 per cent in determining the weight of the maceration water produces an error of approximately 0.35 in the *normal juice factor.*

Effect of errors in determining the weight of the cane upon the normal juice factor.—The actual weight of the cane is 155.7 tons. But let the *normal juice factor* be calculated separately for:

$$Wc = \begin{cases} (a) & 154.143 \text{ tons} & (99 \text{ per cent of the actual weight}) \\ b) & 155.700 \text{ tons} & (\text{the actual weight}) \\ (c) & 157.257 \text{ tons} & (101 \text{ per cent of the actual weight}) \end{cases}$$

Let the other variables involved remain constant at their actual values.

The *normal juice factor* is found to vary with the value chosen for the weight of the cane as follows:

	(*a*)	(*b*)	(*c*)
Value chosen for weight of cane percentage of actual weight	99.0	100.0	101.0
Value obtained for normal juice factor	98.01	97.65	97.28

These results may be summarized as follows:

(a) If the value chosen for the weight of the cane is too low, the *normal juice factor* will be too high; and, conversely, if the value chosen for the weight of the cane is too high, the *normal juice factor* will be too low.

(b) An error of 1.0 per cent in determining the weight of the cane produces an error of approximately 0.36 in the *normal juice factor.*

Effect of errors in determining the weight of mixed juice upon the normal juice factor.—The actual weight of the mixed juice is 192.8 tons. But let the *normal juice factor* be calculated separately for:

Wm =	(a)	190.872 tons	(99 per cent of the actual weight)
	(b)	192.800 tons	(the actual weight)
	(c)	194.728 tons	(101 per cent of the actual weight)

Let the other variables involved remain constant at their actual values.

The *normal juice factor* is found to vary with the value chosen for the weight of the mixed juice as follows:

	(a)	(b)	(c)
Value chosen for weight of mixed juice percentage of actual weight	99.0	100.0	101.0
Value obtained for normal juice factor	97.63	97.646	97.66

These results may be summarized as follows:

(a) If the value chosen for the mixed juice weight is too low, the *normal juice factor* will also be too low; and, conversely, if the value chosen for the mixed juice weight is too high, the *normal juice factor* will also be too high.

(b) An error of 1.0 per cent in the mixed juice weight produces an error of approximately 0.015 in the *normal juice factor*.

(c) The effect upon the *normal juice factor* is so slight, however, that the *normal juice factor* alone can not be considered an effective means of detecting errors in the determination of the mixed juice weights.

Effect of errors in determining Brix of mixed juice upon the normal juice factor.—The actual Brix of the mixed juice is 14.83. But let the *normal juice factor* be obtained separately for:

Bm =	(a)	14.6817	(99 per cent of actual Brix)
	(b)	14.83	(actual Brix)
	(c)	14.9783	(101 per cent of actual Brix)

Let the other variables involved remain constant at their actual values.

The *normal juice factor* is found to vary with the value chosen for the Brix of the mixed juice as follows:

	(a)	(b)	(c)
Value chosen for Brix of mixed juice percentage of actual Brix	99.0	100.0	101.0
Value obtained for normal juice factor	96.70	97.65	98.59

These results may be summarized as follows:

(a) If the value chosen for the Brix of the mixed juice is too low, the *normal juice factor* will also be too low and, conversely, if the value chosen for the Brix of the mixed juice is too high, the *normal juice factor* will also be too high.

(b) An error of 1.0 per cent in determining the Brix of the mixed juice produces an error of approximately 0.94 in the *normal juice factor*.

Effect of errors in determining Brix of crusher juice upon the normal juice factor.—The actual Brix of the crusher juice is 22.29. But let the *normal juice factor* be determined separately for:

Bc =	(a)	22.0671	(99 per cent of actual Brix)
	(b)	22.29	(actual Brix)
	(c)	22.5129	(101 per cent of actual Brix)

Let the other variables involved remain constant at their actual values.

The *normal juice factor* is found to vary with the value chosen for the Brix of the crusher juice as follows:

	(*a*)	(*b*)	(*c*)
Value chosen for Brix of crusher juice percentage of actual Brix.	99.0	100.0	101.0
Value obtained for normal juice factor.....	98.63	97.65	96.68

These results may be summarized as follows:

(a) If the value chosen for the Brix of the crusher juice is too low, the *normal juice factor* will be too high; and, conversely, if the value chosen for the Brix of the crusher juice is too high, the *normal juice factor* will be too low.

(b) An error of 1.0 per cent in determining the Brix of the crusher juice produces an error of approximately 0.97 in the *normal juice factor.*

Effect of errors in determining purity of last expressed juice upon the normal juice factor.—The actual purity of last expressed juice is 74.39. But let the *normal juice factor* be determined separately for:

$$Jl = \begin{vmatrix} (a) & 73.6461 & (99 \text{ per cent of actual purity}) \\ (b) & 74.39 & (\text{actual purity}) \\ (c) & 75.1339 & (101 \text{ per cent of actual purity}) \end{vmatrix}$$

Let the other variables involved remain constant at their actual values.

The *normal juice factor* is found to vary with the value chosen for the purity of last expressed juice as follows:

	(*a*)	(*b*)	(*c*)
Value chosen for purity of last expressed juice percentage of actual purity.....	99.0	100.0	101.0
Value obtained for normal juice factor.....	97.673	97.646	97.619

These results may be summarized as follows:

(a) If the value chosen for the purity of last expressed juice is too low, the *normal juice factor* will be too high; and, conversely, if the value chosen for the purity of last expressed juice is too high, the *normal juice factor* will be too low.

(b) An error of 1.0 per cent in determining the purity of last expressed juice produces an error of approximately 0.027 in the *normal juice factor.*

(c) The effect upon the *normal juice factor* is, however, so slight that the *normal juice factor* can not be considered an effective means of detecting errors in determining the purity of last expressed juice.

Effect of errors in determining percentage of polarization in bagasse upon the normal juice factor.—The actual percentage of polarization in bagasse is 2.18. But let the *normal juice factor* be determined separately for:

$$Pb = \begin{vmatrix} (a) & 2.1582 & (99 \text{ per cent of actual percentage of polarization}) \\ (b) & 2.18 & (\text{actual percentage of polarization}) \\ (c) & 2.2018 & (101 \text{ per cent of actual percentage of polarization}) \end{vmatrix}$$

Let the other variables involved remain constant at their actual values.

The *normal juice factor* is found to vary with the value chosen for the percentage of polarization in bagasse as follows:

	(*a*)	(*b*)	(*c*)
Value chosen for percentage of polarization in bagasse percentage of actual value.....	99.0	100.0	101.0
Value obtained for normal juice factor.....	97.619	97.646	97.673

These results may be summarized as follows:

(a) If the value chosen for percentage of polarization in bagasse is too low, the *normal juice factor* will also be too low; and, conversely, if the value chosen for percentage of polarization in bagasse is too high, the *normal juice factor* will also be too high.

(b) An error of 1.0 per cent in determining the percentage of polarization in bagasse produces an error of 0.027 in the *normal juice factor*.

(c) The effect upon the *normal juice factor* is, however, so slight that the *normal juice factor* can not be considered an effective means of detecting errors in determining the percentage of polarization in bagasse.

Effect of errors in determining percentage of moisture in bagasse upon the normal juice factor.—The actual percentage of moisture in bagasse is 43.5. But let the *normal juice factor* be determined separately for:

$$Mb = \begin{cases} (a) & 43.065 & (99 \text{ per cent of actual percentage of moisture}) \\ (b) & 43.5 & (\text{actual percentage of moisture}) \\ (c) & 43.935 & (101 \text{ per cent of actual percentage of moisture}) \end{cases}$$

Let the other variables involved remain constant at their actual values.

The *normal juice factor* is found to vary with the value chosen for the percentage of moisture in bagasse as follows:

	(*a*)	(*b*)	(*c*)
Value chosen for percentage of moisture in bagasse percentage of actual value	99.0	100.0	101.0
Value obtained for normal juice factor	97.759	97.646	97.533

These results may be summarized as follows:

(a) If the value chosen for percentage of moisture in bagasse is too low, the *normal juice factor* will be too high; and, conversely, if the value chosen for percentage of moisture in bagasse is too high, the *normal juice factor* will be too low.

(b) An error of 1.0 per cent in determining the percentage of moisture in bagasse produces an error of approximately 0.11 in the *normal juice factor*.

CASE B: WHEN THE PERCENTAGE OF FIBER IN CANE IS DETERMINED BY DIRECT ANALYSIS

The actual values of the variables involved in the general formula (14) for the *normal juice factor* are taken as follows:

1.	Percentage of fiber in cane	Fc =	12.49
2.	Weight of cane	Wc =	155.7 tons
3.	Weight of mixed juice	Wm =	192.8 tons
4.	Brix of mixed juice	Bm =	14.83
5.	Brix of crusher juice	Bc =	22.29
6.	Purity of last expressed juice	Jl =	74.39
7.	Percentage of polarization in bagasse	Pb =	2.18
8.	Percentage of moisture in bagasse	Mb =	43.50

It will be noted that these variables are exactly the same as those in "Case A" with the single exception that "Percentage of fiber in cane" replaces "Weight of maceration water."

As in "Case A," let the value of each of the variables be varied in turn while the other variables remain constant at their actual values. And let the *normal juice factor* be calculated in turn for three different values of each variable, its actual value, 99 per cent of its actual value, and 101 per cent of its actual value.

Effect of errors in determining percentage of fiber in cane upon the normal juice factor.—The actual percentage of fiber in cane is 12.49. But let the *normal juice factor* be determined separately for:

$$Fc = \begin{cases} (a) & 12.3651 & \text{(99 per cent of actual percentage of fiber)} \\ (b) & 12.49 & \text{(actual percentage of fiber)} \\ (c) & 12.6149 & \text{(101 per cent of actual percentage of fiber)} \end{cases}$$

Let the other variables involved remain constant at their actual values.

The *normal juice factor* is found to vary with the value chosen for percentage of fiber in cane as follows:

	(*a*)	(*b*)	(*c*)
Value chosen for percentage of fiber in cane percentage of actual value	99.0	100.0	101.0
Value obtained for normal juice factor	97.472	97.646	97.821

These results may be summarized as follows:

(a) If the value chosen for percentage of fiber in cane is too low, the *normal juice factor* will also be too low; and, conversely, if the value chosen for percentage of fiber in cane is too high, the *normal juice factor* will also be too high.

(b) An error of 1.0 per cent in determining percentage of fiber in cane produces an error of approximately 0.17 in the *normal juice factor.*

Effect of errors in determining weight of cane upon the normal juice factor.—The actual weight of cane is 155.7 tons. But let the *normal juice factor* be determined separately for:

$$Wc = \begin{cases} (a) & 154.143 \text{ tons} & \text{(99 per cent of actual weight)} \\ (b) & 155.700 \text{ tons} & \text{(actual weight)} \\ (c) & 157.257 \text{ tons} & \text{(101 per cent of actual weight)} \end{cases}$$

Let the other variables involved remain constant at their actual values.

The *normal juice factor* is found to vary with the value chosen for the weight of cane as follows:

	(*a*)	(*b*)	(*c*)
Value chosen for weight of cane percentage of actual weight	99.0	100.0	101.0
Value obtained for the normal juice factor	98.60	97.65	96.71

These results may be summarized as follows:

(a) If the value chosen for weight of cane is too low, the *normal juice factor* will be too high; and, conversely, if the value chosen for weight of cane is too high, the *normal juice factor* will be too low.

(b) An error of 1.0 per cent in determining the weight of cane produces an error of approximately 0.94 in the *normal juice factor.*

Effect of errors in determining weight of mixed juice upon the normal juice factor.—The actual weight of mixed juice is 192.8 tons. But let the *normal juice factor* be determined separately for:

$$Wm = \begin{cases} (a) & 190.872 \text{ tons} & \text{(99 per cent of actual weight)} \\ (b) & 192.800 \text{ tons} & \text{(actual weight)} \\ (c) & 194.728 \text{ tons} & \text{(101 per cent of actual weight)} \end{cases}$$

Let the other variables involved remain constant at their actual values.

The *normal juice factor* is found to vary with the value chosen for the weight of mixed juice as follows:

	(*a*)	(*b*)	(*c*)
Value chosen for weight of mixed juice percentage of actual weight	99.0	100.0	101.0
Value obtained for normal juice factor	96.70	97.65	98.59

These results may be summarized as follows:

(a) If the value chosen for weight of mixed juice is too low, the *normal juice factor* will also be too low; and, conversely, if the value chosen for weight of mixed juice is too high the *normal juice factor* will also be too high.

(b) An error of 1.0 per cent in determining the weight of mixed juice produces an error of approximately 0.94 in the *normal juice factor.*

Effect of errors in determining Brix of mixed juice upon the normal juice factor.—The actual Brix of mixed juice is 14.83. But let the *normal juice factor* be determined separately for:

$$Bm = \begin{cases} (a) & 14.6817 & (99 \text{ per cent of actual Brix}) \\ (b) & 14.83 & (\text{actual Brix}) \\ (c) & 14.9783 & (101 \text{ per cent of actual Brix}) \end{cases}$$

Let the other variables involved remain constant at their actual values

The *normal juice factor* is found to vary with the value chosen for Brix of mixed juice as follows:

	(*a*)	(*b*)	(*c*)
Value chosen for Brix of mixed juice percentage of actual value	99.0	100.0	101.0
Value obtained for normal juice factor	96.70	97.65	98.59

These results may be summarized as follows:

(a) If the value chosen for Brix of mixed juice is too low, the *normal juice factor* will also be too low; and, conversely, if the value chosen for Brix of mixed juice is too high, the *normal juice factor* will also be too high.

(b) An error of 1.0 per cent in determining the Brix of mixed juice produces an error of approximately 0.94 in the *normal juice factor.*

Effect of errors in determining Brix of crusher juice upon the normal juice factor.—The actual Brix of crusher juice is 22.29. But let the *normal juice factor* be determined separately for:

$$Bc = \begin{cases} (a) & 22.0671 & (99 \text{ per cent of actual Brix}) \\ (b) & 22.29 & (\text{actual Brix}) \\ (c) & 22.5129 & (101 \text{ per cent of actual Brix}) \end{cases}$$

Let the other variables involved remain constant at their actual values.

The *normal juice factor* is found to vary with the value chosen for Brix of crusher juice as follows:

	(*a*)	(*b*)	(*c*)
Value chosen for Brix of crusher juice percentage of actual value	99.0	100.0	101.0
Value obtained for normal juice factor	98.63	97.65	96.68

These results may be summarized as follows:

(a) If the value chosen for Brix of crusher juice is too low, the *normal juice factor* will be too high; and, conversely, if the value chosen for Brix of crusher juice is too high, the *normal juice factor* will be too low.

(b) An error of 1.0 per cent in determining the Brix of crusher juice produces an error of approximately 0.97 in the *normal juice factor*.

Effect of errors in determining purity of last expressed juice upon the normal juice factor.—The actual purity of last expressed juice is 74.39. But let the *normal juice factor* be determined separately for:

$$Jl = \begin{cases} (a) & 73.6461 & (99 \text{ per cent of actual purity}) \\ (b) & 74.39 & (\text{actual purity}) \\ (c) & 75.1339 & (101 \text{ per cent of actual purity}) \end{cases}$$

Let the other variables involved remain constant at their actual values.

The *normal juice factor* is found to vary with the value chosen for purity of last expressed juice as follows:

	(a)	(b)	(c)
Value chosen for purity of last expressed juice percentage of actual value	99.0	100.0	101.0
Value obtained for normal juice factor	97.684	97.646	97.610

These results may be summarized as follows:

(a) If the value chosen for purity of last expressed juice is too low, the *normal juice factor* will be too high; and, conversely, if the value chosen for purity of last expressed juice is too high, the *normal juice factor* will be too low.

(b) An error of 1.0 per cent in determining the purity of last expressed juice produces an error of approximately 0.037 in the *normal juice factor*.

(c) The effect upon the *normal juice factor* is so slight, however, that the *normal juice factor* can not be considered an effective means of detecting errors in the determination of the purity of last expressed juice.

Effect of errors in determining percentage of polarization in bagasse upon the normal juice factor.—The actual percentage of polarization in bagasse is 2.18. But let the *normal juice factor* be determined separately for:

$$Pb = \begin{cases} (a) & 2.1582 & (99 \text{ per cent of actual value}) \\ (b) & 2.18 & (\text{actual value}) \\ (c) & 2.2018 & (101 \text{ per cent of actual value}) \end{cases}$$

Let the other variables involved remain constant at their actual values.

The *normal juice factor* is found to vary with the value chosen for percentage of polarization in bagasse as follows:

	(a)	(b)	(c)
Value chosen for percentage of polarization in bagasse percentage of actual value	99.0	100.0	101.0
Value obtained for normal juice factor	97.610	97.646	97.684

These results may be summarized as follows:

(a) If the value chosen for percentage of polarization in bagasse is too low, the *normal juice factor* will also be too low; and, conversely, if the value chosen for percentage of polarization in bagasse is too high, the *normal juice factor* will also be too high.

(b) An error of 1.0 per cent in determining the percentage of polarization in bagasse produces an error of approximately 0.037 in the *normal juice factor*.

(c) The effect upon the *normal juice factor* is so slight, however, that the *normal juice factor* can not be considered an effective means of detecting errors in the determination of the percentage of polarization in bagasse.

Effect of errors in determining percentage of moisture in bagasse upon the normal juice factor.—The actual percentage of moisture in bagasse is 43.50. But let the *normal juice factor* be determined separately for:

$$Mb = \begin{cases} (a) & 43.065 & (99 \text{ per cent of actual percentage of moisture}) \\ (b) & 43.5 & (\text{actual percentage of moisture}) \\ (c) & 43.935 & (101 \text{ per cent of actual percentage of moisture}) \end{cases}$$

Let the other variables involved remain constant at their actual values.

The *normal juice factor* is found to vary with the value chosen for percentage of moisture in bagasse as follows:

	(*a*)	(*b*)	(*c*)
Value chosen for percentage of moisture in bagasse percentage of actual value	99.0	100.0	101.0
Value obtained for normal juice factor	97.618	97.646	97.675

These results may be summarized as follows:

(a) If the value chosen for percentage of moisture in bagasse is too low, the *normal juice factor* will also be too low; and, conversely, if the value chosen for percentage of moisture in bagasse is too high, the *normal juice factor* will also be too high.

(b) An error of 1.0 per cent in determining the percentage of moisture in bagasse produces an error of approximately 0.028 in the *normal juice factor*.

(c) The effect upon the *normal juice factor* is so slight, however, that the *normal juice factor* can not be considered an effective means of detecting errors in the determination of the percentage of moisture in bagasse.

WHAT ABNORMAL VALUES FOR THE NORMAL JUICE FACTOR INDICATE

It is evident that an abnormal value for the *normal juice factor* indicates an error in the determination of one or more of the variables involved. From the foregoing analysis of the effect upon the *normal juice factor* of errors in determining the variables, it may be predicted that:

CASE A: WHEN THE PERCENTAGE OF FIBER IN CANE IS DETERMINED INDIRECTLY

If the normal juice factor is abnormally low:—

(a) The weight of maceration water may be too low.
(b) The weight of cane may be too high.
(c) The Brix of mixed juice may be too low.
(d) The Brix of crusher juice may be too high.
(e) The percentage of moisture in bagasse may be too high.
(f) Two or more of the above errors may exist simultaneously.

If the normal juice factor is abnormally high:—

(a) The weight of maceration water may be too high.
(b) The weight of cane may be too low.
(c) The Brix of mixed juice may be too high.
(d) The Brix of crusher juice may be too low.
(e) The percentage of moisture in bagasse may be too low.
(f) Two or more of the above errors may exist simultaneously.

CASE B: WHEN THE PERCENTAGE OF FIBER IN CANE IS DETERMINED BY DIRECT ANALYSIS

If the normal juice factor is abnormally low:—

(a) The percentage of fiber in cane may be too low.
(b) The weight of cane may be too high.
(c) The weight of mixed juice may be too low.
(d) The Brix of mixed juice may be too low.
(e) The Brix of crusher juice may be too high.
(f) Two or more of the above errors may exist simultaneously.

If the normal juice factor is abnormally high:—

(a) The percentage of fiber in cane may be too high.
(b) The weight of cane may be too low.
(c) The weight of mixed juice may be too high.
(d) The Brix of mixed juice may be too high.
(e) The Brix of crusher juice may be too low.
(f) Two or more of the above errors may exist simultaneously.

PRACTICAL APPLICATION OF THE NORMAL JUICE FACTOR TO LABORATORY CONTROL

It will be noted that an abnormal value for the *normal juice factor* does not of itself indicate the exact nature of the error to which it calls attention. The abnormal value for the *normal juice factor* simply sounds a general alarm that a serious error has been made in the determination of one or more of the variables involved. It then becomes the duty of the chemist to apply such other tests and checks as are available in order to determine the exact nature of the error. In actual practice, sufficient checks and counterchecks are usually employed so that the exact nature of the error can be determined without great difficulty.

It also not infrequently happens that, as a result of some accident, no direct analysis or direct measurement is available for the determination of one of the variables involved in the general formula for the *normal juice factor*. In such a case, the unknown variable can be calculated with great accuracy by substituting the known values of the other variables and an average value for the *normal juice factor* in the general formula for the *normal juice factor*, or preferably in the subsidiary formula expressing the value of the unknown variable in terms of the known variables and of the *normal juice factor*.

The calculation of the Brix of the normal juice and of the *normal juice factor* by the indirect method herein described should be made a part of the regular laboratory routine in the same manner that the calculation of the Java Ratio is a part of the regular laboratory routine.

The *normal juice factor* is, as a control factor, far more reliable than the generally used Java Ratio for the very obvious reason that the *normal juice factor* is far more nearly constant than is the Java Ratio. The Java Ratio may, however, be used in connection with, and supplementary to, the *normal juice factor* to achieve a closer chemical control than would be possible if either were used alone.

Normal values for both the *normal juice factor* and the Java Ratio are, taken together, a very strong indication that the fundamental direct analyses and direct measurements upon which rests the whole structure of chemical control have been correctly determined. An abnormal value for either of these factors is an equally strong indication that there is a serious error either in the laboratory calculations or in one or more of these fundamental direct analyses or direct measurements. The careful chemist will not allow this warning to pass unheeded.

EXAMPLES OF THE USE OF THE NORMAL JUICE FACTOR

The examples which follow are actual cases of the use of the *normal juice factor* taken from the laboratory records of the writer, who developed and used (in 1921) formulas (1) and (15) for calculating dilution percentage of normal juice. From this earliest use of a logical formula for obtaining the Brix of the normal juice, the writer developed and applied during 1923 the general formula for the *normal juice factor*.

For the examples which follow, the standards taken as representing normal values for the *normal juice factor* and for the Java Ratio are the true averages for the entire season as follows:

Average normal juice factor	97.42
Average Java Ratio	83.58
Average percentage deducted from gross cane weight for trash	1.80

The average trash deduction is given because, as will be shown hereafter, the *normal juice factor*, as well as the Java Ratio, increases as the percentage deducted for trash increases. Hence, what is a normal value for the *normal juice factor* with a 1.8 per cent trash deduction would not be a normal value with a 2.5 per cent trash deduction.

It is expected that the *normal juice factor* will vary between 97.0 and 98.0 with a 1.8 per cent trash deduction.

It is expected that the Java Ratio will vary between 82.5 and 84.5 with a 1.8 per cent deduction for trash.

If the values obtained for the *normal juice factor* and for the Java ratio fall within these limits, it is assumed that the weights, direct analyses, and calculations are substantially correct. If values above or below these limits are obtained, a search is made for the error which is presumed to exist.

The examples follow:

RECORDED WEIGHT OF MACERATION WATER TOO LOW

Recorded weights and average analyses:—

Maceration, tons	364.800
Cane, net tons	1086.778
Percentage deducted for trash	1.5
Mixed juice, tons	1258.251
Brix	14.93
Percentage of sucrose (Clerget)	13.16
Crusher juice, Brix	20.65
Percentage of polarization	18.60
Last expressed juice, A. Purity	74.89
Bagasse, percentage of polarization	2.00
Percentage of moisture	42.08

Calculations based on recorded weights and analyses:—

Percentage of soluble solids in bagasse	2.67
Percentage of fiber in bagasse	55.25
Bagasse percentage of cane	17.79
Mixed juice percentage of cane	115.77
Polarization in bagasse percentage of cane	0.36
Sucrose in mixed juice percentage of cane	15.24
Percentage of sucrose in cane	15.60
Percentage of fiber in cane	9.83

Soluble solids in bagasse percentage of cane	0.47
Soluble solids in mixed juice percentage of cane	17.28
Total soluble solids percentage of cane	17.75
Normal juice percentage of cane	90.17
Brix of normal juice	19.69
Dilution percentage of normal juice	31.88
Normal juice factor	95.35
Java Ratio	83.87

It will be observed that the value obtained for the *normal juice factor* is abnormally low, while the Java Ratio, on the other hand, is quite normal. This is an indication that neither the cane nor the mixed juice weight is at fault; for a serious error in either of these weights would affect the Java ratio.

A careful check of the calculation of the average Brix of the crusher and of the mixed juice failed to reveal any error here. The percentage of moisture in bagasse is about the same as the previous average and is already so low that a value enough lower to produce a normal value for the *normal juice factor* could not be considered possible. By a process of elimination, the conclusion was reached that the only possible explanation for the abnormally low *normal juice factor* is that the reported weight of the maceration water is far too low. This presumption is further borne out by the fact that an abnormally low value is obtained for the percentage of fiber in cane. The average percentage of fiber in cane to date was 12.24. The 9.83 per cent fiber in cane obtained above is a much wider variation from the average than usual.

The maceration water was measured in a tank which was filled until the overflow level was reached and then emptied into a supply tank below. A Bristol liquid level recorder was installed on the measuring tank to record the number of tanks of water measured. The number of tanks recorded on the chart was recounted and failed to reveal any error here. The calculation of the average weight per tank was checked and found correct, and the calculation of the total weight of maceration water corresponded to the number of tanks recorded on the chart. It still seemed so certain, however, that the record for maceration water used was at fault that a watch was set upon the tank boy whose duty it was to measure the maceration water; and the following night he was caught running cold water into the maceration supply tank by means of a rubber hose connected to a nearby cold water line. The cold water did not pass through the measuring tank and so the quantity of cold water used was not recorded. The tank boy gave as an excuse for adding the cold water that "it prevented too much hot steam from rising from the maceration supply tank."

Since the exact quantity of maceration water used was unknown, it now became necessary to estimate the weight of maceration water by means of an assumed *normal juice factor*. This was done by assuming 97.0 as the minimum probable *normal juice factor* and then calculating the corresponding weight of maceration water by substitution in formula (13). This gave 389.5 tons as the minimum weight of maceration water which could be considered possible. As the percentage of fiber in cane corresponding to this weight is still somewhat below the average, it is probable that the quantity of maceration water actually used

was somewhat higher, but it was desired to keep the estimate on the conservative side. The corrected calculations follow:

Corrected calculations based on assumed normal juice factor.—

Assumed normal juice factor	97.0
Corresponding weight of maceration water (tons)	389.5
Bagasse percentage of cane	20.06
Polarization in bagasse percentage of cane	0.40
Sucrose in mixed juice percentage of cane	15.24
Percentage of sucrose in cane	15.64
Percentage of fiber in cane	11.08
Soluble solids in bagasse percentage of cane	0.54
Soluble solids in mixed juice percentage of cane	17.28
Total soluble solids percentage of cane	17.82
Normal juice percentage of cane	88.92
Brix of normal juice	20.04
Dilution percentage of normal juice	34.23
Java Ratio	84.09

MIXED JUICE WEIGHT TOO LOW

Recorded weights and average analyses.—

Maceration, tons	380.000
Cane, net tons	1083.781
Percentage deducted for trash	1.5
Mixed juice, tons	1202.598
Brix	16.10
Percentage of sucrose (Clerget)	14.16
Crusher juice, Brix	21.92
Percentage of polarization	19.65
Last expressed juice, A. Purity	77.04
Bagasse, percentage of polarization	1.34
Percentage of moisture	40.90

Calculations based on recorded weights and analyses.—

Percentage of soluble solids in bagasse	1.74
Percentage of fiber in bagasse	57.36
Bagasse percentage of cane	24.10
Mixed juice percentage of cane	110.96
Polarization in bagasse percentage of cane	0.32
Sucrose in mixed juice percentage of cane	15.71
Percentage of sucrose in cane	16.03
Percentage of fiber in cane	13.82
Soluble solids in bagasse percentage of cane	0.42
Soluble solids in mixed juice percentage of cane	17.86
Total soluble solids percentage of cane	18.28
Normal juice percentage of cane	86.18
Brix of normal juice	21.21
Normal juice factor	96.76
Java Ratio	81.58

It will be observed that while both the *normal juice factor* and the Java ratio are below the average, the Java Ratio is affected to a much greater degree than the *normal juice factor*. It will also be noted that the percentage of fiber in cane is abnormally high, 13.82, as compared with an average to date of 12.09. Both of these conditions would obtain if the reported mixed juice weight were

too low. The writer, having arrived at this conclusion, went out to the juice weighing scales and found the discharge valve of one of the scale tanks leaking badly. From the rate at which leakage was then taking place, and from the time at which the leakage was found to have begun, it was estimated that 34 tons of unweighed juice might have passed through during the preceding 24 hours. The actual weight of the mixed juice was, therefore, estimated at 1236.598 tons instead of the reported 1202.598 tons. The corrected calculations based upon the estimated mixed juice weight follow:

Corrected calculations based on estimated weight of mixed juice.—

Estimated weight of mixed juice	1236.598
Bagasse percentage of cane	20.96
Mixed juice percentage of cane	114.10
Polarization in bagasse percentage of cane	0.28
Sucrose in mixed juice percentage of cane	16.16
Percentage of sucrose in cane	16.44
Percentage of fiber in cane	12.02
Soluble solids in bagasse percentage of cane	0.36
Soluble solids in mixed juice percentage of cane	18.37
Total soluble solids percentage of cane	18.73
Normal juice percentage of cane	87.98
Brix of normal juice	21.29
Normal juice factor	97.13
Java Ratio	83.66

As normal values are now obtained for both the *normal juice factor* and the Java Ratio and for the percentage of fiber in cane, it is assumed that the estimated weight of mixed juice is approximately correct.

BRIX OF MIXED JUICE TOO LOW

Recorded weights and average analyses.—

Maceration, tons	298.300
Cane, tons	1036.971
Percentage deducted for trash	1.5
Mixed juice, tons	1111.111
Brix	16.30
Percentage of sucrose (Clerget)	14.26
Crusher juice, Brix	21.33
Percentage of polarization	19.03
Last expressed juice, A. Purity	75.68
Bagasse, percentage of polarization	1.86
Percentage of moisture	41.45

Calculations based on recorded weights and average analyses.—

Percentage of soluble solids in bagasse	2.46
Percentage of fiber in bagasse	56.09
Bagasse percentage of cane	21.62
Mixed juice percentage of cane	107.15
Polarization in bagasse percentage of cane	0.40
Sucrose in mixed juice percentage of cane	15.28
Percentage of sucrose in cane	15.68
Percentage of fiber in cane	12.13
Soluble solids in bagasse percentage of cane	0.53
Soluble solids in mixed juice percentage of cane	17.47

Total soluble solids percentage of cane	18.00
Normal juice percentage of cane	87.87
Brix of normal juice	20.48
Dilution percentage of normal juice	25.64
Normal juice factor	96.02
Java Ratio	82.40

Both the Java Ratio and the *normal juice factor* are too low. Upon checking over the hourly analyses of the mixed juice, it was noted that three analyses made during the night showed a very much lower Brix and polarization than the rest. From the record of the tons of cane ground hour by hour and the charts showing the number of tanks of maceration water measured and the number of tanks of mixed juice weighed hour by hour, it was determined that the grinding rate and the quantity of maceration applied had both been uniform. As the Brix of the crusher juice was practically constant throughout the period, it was very evident that the three samples of mixed juice whose analyses showed such a low Brix had been diluted with water, either accidentally or by design. These three analyses were, therefore, discarded and a true average Brix and percentage of sucrose (Clerget) recalculated from the remaining analyses. The recalculated averages were: Brix, 16.46; percentage of sucrose (Clerget), 14.40. The calculations based on these averages follow:

Calculations based on recalculated brix and percentage of sucrose of mixed juice.—

Recalculated Brix of mixed juice	16.46
Recalculated percentage of sucrose in mixed juice	14.40
Polarization in bagasse percentage of cane	0.40
Sucrose in mixed juice percentage of cane	15.43
Percentage of sucrose in cane	15.83
Soluble solids in bagasse percentage of cane	0.53
Soluble solids in mixed juice percentage of cane	17.64
Total soluble solids percentage of cane	18.17
Normal juice percentage of cane	87.87
Brix of normal juice	20.68
Normal juice factor	96.95
Java Ratio	83.18

It will be noted that the *normal juice factor* is still slightly too low, but as the error is evidently not great, the analyses were allowed to stand as recalculated.

BRIX OF CRUSHER JUICE TOO LOW

Recorded weights and average analyses.—

Maceration, tons	290.700
Cane, net tons	648.343
Percentage deducted for trash	2.27
Mixed juice, tons	801.656
Brix	15.00
Percentage of sucrose (Clerget)	13.00
Crusher juice, Brix	21.48
Percentage of polarization	19.26
Last expressed juice, A. Purity	72.96
Bagasse, percentage of polarization	1.30
Percentage of moisture	40.40

Calculations based on recorded weights and analyses.—

Percentage of soluble solids in bagasse	1.78
Percentage of fiber in bagasse	57.82
Bagasse percentage of cane	21.19
Mixed juice percentage of cane	123.65
Polarization in bagasse percentage of cane	0.28
Sucrose in mixed juice percentage of cane	16.07
Percentage of sucrose in cane	16.35
Percentage of fiber in cane	12.25
Soluble solids in bagasse percentage of cane	0.38
Soluble solids in mixed juice percentage of cane	18.55
Total soluble solids percentage of cane	18.93
Normal juice percentage of cane	87.75
Brix of normal juice	21.57
Normal juice factor	100.42
Java Ratio	84.89

The value obtained for the *normal juice factor* is abnormally high. Search for the error revealed it to be in the calculation of the average Brix of the crusher juice. The true average of the individual analyses gave 21.95 as the Brix of the crusher juice. Calculated on this Brix, the *normal juice factor* becomes 98.27. This is still somewhat higher than the average as is also the Java Ratio, but these high values are accounted for by the fact that the trash deduction (2.27 per cent) is also somewhat above the average.

DEGREE OF VARIABILITY OF THE NORMAL JUICE FACTOR

The *normal juice factor* has been found to vary within very narrow limits and to be, in fact, almost constant. Noel Deerr says on page 551 of "Cane Sugar" (Revised Edition): "As a result of analysis he (Noel Deerr) found on an average that the relation Brix of first expressed juice $\times 0.975 =$ Brix of absolute (Normal) juice held. This figure refers to an extraction of about 60 per cent on the weight of the cane." Noel Deerr bases his conclusion upon the direct analysis of the normal juice as obtained by means of dry milling tests.

The writer determined the average Brix of the normal juice daily by the indirect method given above over a period of four months during which time the factory ground a total of ninety thousand tons of cane. The *normal juice factor* thus obtained varied from day to day between 97.0 and 98.0, and the true average for the entire period was 97.42, which is extremely close to the figure given by Noel Deerr. The value 97.42 was calculated from the net weight of the cane after deducting 1.8 per cent from the gross cane weight for trash.

THE CHIEF CAUSE OF VARIATIONS IN THE NORMAL JUICE FACTOR FROM DAY TO DAY

The writer has found that, as a rule, the Java Ratio and the *normal juice factor* show greater variations from day to day than from week to week. The wider variations from day to day are due chiefly to failure, when the mill is running continuously, to close the cane weight, mixed juice weight, and maceration weight at exactly corresponding points, at the end of each twenty-four hour period. This is a practical difficulty which is very difficult to entirely overcome in the *daily* laboratory calculations. This difficulty disappears automatically, however, at the end of the week when the total weights of cane, mixed juice, and maceration for the entire week's run are obtained. The *normal juice factor* may be a little too high for one day and a little too low for the next, but the average for the week will be correct. By taking care to close the mixed juice, cane, and maceration weights at as nearly corresponding points as possible at the end of each twenty-four hour period, the chemist may avoid excessive fluctuations in the Java Ratio and the *normal juice factor* from day to day.

The procedure followed by the writer is as follows:

At the beginning of the week is noted the time which elapses between the delivery of the first cane to the crusher and the arrival of the first cane at the point of application of the maceration water. This is taken as the approximate difference in time to be observed between the closing of the cane and maceration weights at the end of each twenty-four hour period. There is also noted at the beginning of the week the time which elapses between the delivery of the first cane to the crusher and the emergence of the first bagasse from the last mill. This is taken as the approximate difference in time to be observed between the closing of the cane and mixed juice weights.

At the end of each twenty-four-hour period, the cane weight is closed first. There is noted the time of delivery to the crusher of the last cane for the preceding twenty-four-hour period. After the proper intervals of time have elapsed, the maceration and mixed juice weights are also closed.

It is obvious that if the *normal juice factor* is to be of the greatest practical utility as a control factor, artificial variations due to failure to close the cane, mixed juice, and maceration weights at exactly corresponding points must be reduced to the minimum.

EFFECT OF A TRASH DEDUCTION

Effect upon factory control data in general.—It is generally recognized that an abnormally high trash deduction results in misleading and abnormally high values for many of the basic factory control figures. It was with this fact in mind that the first annual conference of Philippine sugar men in 1921 adopted a resolution fixing one per cent of the gross weight of the cane as the standard minimum trash deduction for all Philippine factories. While excellent reasons may be advanced for making a trash deduction, the fact should not be overlooked that *any* trash deduction, however small, is in a sense an arbitrary deduction which exerts a disturbing influence upon the most important factory control data.

The principal reason advanced for making a trash deduction is that the trash is not really a part of the cane and that, for example, the percentage of sucrose in cane, if based upon the gross weight (including the trash) of the cane, represents the cane as of poorer quality than it actually is. Hence, the practice has become common to deduct the estimated amount of the trash and to calculate the percentage of sucrose in cane upon the "net" weight of the cane thus obtained. This deduction would be perfectly logical provided it approximated the actual weight of the trash and if a similar deduction were made for the trash contained in the bagasse and in the mixed juice after it has passed through the mill. Unfortunately, not only is the trash deduction at the cane scales far in excess of the actual weight of the trash, but also no such allowance is made for the trash content of the bagasse and mixed juice.

It can be demonstrated mathematically that any variation in the deduction for trash at the cane scales produces a similar variation in such basic control factors as the Java Ratio and the *normal juice factor*. The effect of variation in the trash deduction upon these and other laboratory control figures should, therefore, be thoroughly understood and the allowance made in all comparisons of the control data for different factories or for the same factory at different periods.

Effect upon the normal juice factor.—The effect of variation upon the *normal juice factor* may be demonstrated mathematically as presented in Tables I and II.

TABLE I.—*Case A: When the percentage of fiber in cane is determined indirectly by measuring (or weighing) the quantity of maceration applied.*

		How obtained.	Calculated on				
			No trash deduction.	1 per cent trash deduction.	2 per cent trash deduction.	2.27 per cent trash deduction.	3 per cent trash deduction.
1.	Gross cane weight, tons	weighed	158.065	158.065	158.065	158.065	158.065
2.	Deducted for trash, tons	estimated		1.581	3.162	3.594	4.743
3.	Net cane weight, tons	(1)—(2)	158.065	156.484	154.903	154.471	153.322
4.	Add tons maceration applied	measured	74.100	74.100	74.100	74.100	74.100
5.	Net cane plus maceration, tons	(3)+(4)	232.165	230.584	229.003	228.571	227.422
6.	Deduct tons mixed juice	weighed	192.849	192.849	192.849	192.849	192.849
7.	Tons, bagasse	(5)—(6)	39.316	37.735	36.154	35.722	34.573
8.	Purity, last mill juice	analysis	74.39	74.39	74.39	74.39	74.39
9.	Percentage of polarization bagasse	analysis	2.18	2.18	2.18	2.18	2.18
10.	Percentage of moisture in bagasse	analysis	43.50	43.50	43.50	43.50	43.50
11.	Percentage of soluble solids in bagasse	(9) ÷ (8)	2.93	2.93	2.93	2.93	2.93
12.	Percentage of fiber in bagasse	100—[(10)+(11)]	53.57	53.57	53.57	53.57	53.57
13.	Bagasse percentage of cane	(7) ÷ (3)	24.873	24.114	23.340	23.125	22.549
14.	Percentage of fiber in cane	(12)×(13)	13.324	12.918	12.503	12.388	12.079
15.	Mixed juice percentage of cane	(6) ÷ (3)	122.006	123.239	124.497	124.845	125.780
16.	Brix mixed juice	analysis	14.83	14.83	14.83	14.83	14.83
17.	Soluble solids in mixed juice percentage of cane	(16)×(15)	18.093	18.276	18.463	18.515	18.653
18.	Soluble solids in bagasse percentage of cane	(11)×(13)	0.729	0.707	0.684	0.678	0.661
19.	Total soluble solids percentage of cane	(17)+(18)	18.822	18.983	19.147	19.193	19.314
20.	Normal (absolute) juice percentage of cane	100—(14)	86.676	87.082	87.497	87.612	87.921
21.	Brix normal juice	(19) ÷ (20)	21.715	21.799	21.883	21.907	21.967
22.	Brix crusher juice	analysis	22.29	22.29	22.29	22.29	22.29
23.	Normal juice factor	(21) ÷ (22)	97.420	97.797	98.174	98.282	98.551

TABLE II.—*Case B: When the percentage of fiber in cane can be determined by direct analysis.*

		How obtained.	Calculated on				
			No trash deduction.	1 per cent trash deduction.	2 per cent trash deduction.	2.27 per cent trash deduction.	3 per cent trash deduction.
24.	Percentage of fiber in cane	analysis	12.50	12.50	12.50	12.50	12.50
25.	Bagasse percentage of cane	(24) ÷ (12)	23.33	23.33	23.33	23.33	23.33
26.	Soluble solids in bagasse percentage of cane	(11)×(25)	0.684	0.684	0.684	0.684	0.684
27.	Soluble solids in mixed juice percentage of cane	see (17)	18.093	18.276	18.463	18.515	18.653
28.	Total soluble solids percentage of cane	(26)+(27)	18.777	18.960	19.147	19.199	19.337
29.	Normal (absolute) juice percentage of cane	100—(24)	87.50	87.50	87.50	87.50	87.50
30.	Brix, normal juice	(28) ÷ (29)	21.459	21.669	21.882	21.942	22.099
31.	Normal juice factor	(30) ÷ (22)	96.272	97.214	98.170	98.439	99.143

The column in Table I headed "2.27 per cent trash deduction" represents the actual milling results for the last day's run of the four months' period previously mentioned. The cane scales were checked immediately prior to the run and especial care was taken to see that all analyses and weights were accurately determined. The maceration water was measured and its weight calculated from the measurement. No direct fiber analysis was made, and the percentage of fiber in cane was calculated, as indicated, indirectly from the quantity of maceration applied.

For Table II, the same weights and analyses were taken as for Table I, except that it is assumed that the maceration was not measured and that the percentage of fiber in cane was obtained by direct analysis. The value assumed for the percentage of fiber in cane was obtained as follows:

(a) The sample of cane chosen for a direct fiber analysis is always clean cane, that is, free from trash. There is obtained, therefore, by direct analysis only the percentage of fiber in clean cane. The trash, being mainly insoluble material, would, if not removed from the sample, result in a higher percentage of fiber in cane than results from the analysis of clean cane.

(b) It is not possible to separate the trash from the bagasse sample. The percentage of fiber in bagasse obtained by direct analysis, therefore, includes the trash.

(c) A portion of the trash enters into the mixed juice and later is extracted as mud by the filter presses. The mud for this particular run was composed of water, about 65 per cent; soluble solids, about 5 per cent; and insoluble solids, or trash, about 30 per cent. The weight of the press cake was 1.5 per cent of the gross weight of the cane. The trash entering into the mixed juice was, therefore, (.015×30.0) about 0.45 per cent of the weight of the cane.

(d) The actual total trash for that run is estimated at not to exceed 1.45 per cent of the gross weight of the cane. The trash remaining in the bagasse would then be about 1.0 per cent of the gross weight of the cane. Since the trash which entered into the mixed juice is included in the mixed juice weight, the actual gross weight of the bagasse including trash is obtained by adding the weight of maceration to the initial gross cane weight and from the sum deducting the weight of mixed juice. Hence, the actual gross weight of the bagasse is obtained as (158.065+74.100 — 192.849) 39.316 tons. The gross bagasse percentage of cane then is (39.316÷158.065) 24.873. Hence the trash remaining in the bagasse would be (1.0÷0.24873) 4.02 per cent of the gross bagasse. The percentage of fiber in the gross bagasse was 53.57. If all of the trash be considered to be fiber, the net percentage of fiber in the bagasse due clean cane would be (53.57—4.02) 49.55. Now, if the trash be deducted from the gross bagasse, the net bagasse due clean cane is (100—4.02) 96.98 per cent of the gross bagasse. And the fiber in the net bagasse due clean cane is (49.55÷96.98) 51.09 per cent.

(e) The weight of the net bagasse due clean cane would be (39.316× .9698) 38.129 tons. The net clean cane would be (158.065× .9855) 155.773 tons. And the net bagasse due clean cane percentage of clean cane would be 24.48 per cent.

(f) Whence the estimated percentage of fiber in clean cane would be (51.09×0.2448) 12.5.

Summary of effect of trash deduction upon normal juice factor.—From the preceding analysis, it will be observed:

1. That when the percentage of fiber in cane is determined indirectly by measuring the quantity of maceration used, each additional per cent increase in the deduction for trash increases the *normal juice factor* about 0.4 of 1 per cent.

2. That when the percentage of fiber in cane is determined by direct analysis, each additional 1 per cent increase in the deduction for trash increases the *normal juice factor* about 1 per cent.

3. This difference in the effect of variation in the trash deduction upon the *normal juice factor* is due to the fact that the percentage of fiber in cane, and hence the bagasse percentage of cane, when determined by direct analysis, remain constant irrespective of variations in the deduction for trash, whereas when the percentage of fiber in cane is determined indirectly by measuring the quantity of maceration used, both the percentage of fiber in cane and the bagasse percentage of cane decrease as the deduction for trash increases.

4. It follows that it is extremely desirable to determine the percentage of fiber in cane indirectly by measuring (or weighing) the quantity of maceration used, not alone because the fiber determination thus made is likely to be more accurate than by direct analysis, but also because the effect of variations in the deduction for trash upon the *normal juice factor* is much less than is the case where the percentage of fiber in cane is determined by direct analysis.

5. It also follows that the deduction for trash should be as nearly uniform as possible in order that the *normal juice factor* may be as nearly constant as possible.

EFFECT OF VARIATION IN EXTRACTION OBTAINED BY CRUSHER (OR FIRST MILL) UPON THE NORMAL JUICE FACTOR

The writer has been unable to observe that such small variations in the juice extraction obtained by the crusher (or first mill) as occur from day to day in a factory had any appreciable effect upon the *normal juice factor.*

That variations in the juice extraction obtained by the crusher (or first mill) would have some effect upon the *normal juice factor* may be inferred logically from the fact that the Brix of the crusher juice is greater than the Brix of the normal juice. Since the crusher juice is the extracted portion of the normal juice, it follows that the Brix of the unextracted (residual) portion of the normal juice must be less than the Brix of the normal juice. As the juice extraction increases, the Brix of the crusher juice must approach the Brix of the normal juice as a limit, so that with 100 per cent juice extraction the Brix of the crusher juice would be the same as the Brix of the normal juice; in which case the normal juice factor would be 100. We may, therefore, express this relationship by saying that as the juice extraction obtained by the crusher approaches 100 the normal juice factor also approaches 100 as a limit, though not necessarily in uniform ratio.

That any possible variation in the juice extraction obtained by the crusher would not, however, produce any great variation in the *normal juice factor,* may be predicted from the fact that Noel Deerr found the *normal juice factor* to be 97.5 when the juice extraction was 60 per cent. It follows that an increase of 40 units in the juice extraction would produce an increase of only 2.5 units in the *normal juice factor.*

If the increase in the *normal juice factor* bore a constant ratio to the increase in the juice extraction, the *normal juice factor* might then be predicted to vary with the juice extraction as follows:

Normal juice extracted by crusher.	*Normal juice factor.*
per cent	
40	96.25
50	96.88
60	97.5
70	98.13
80	98.75
90	99.38
100	100.00

In actual practice, it is found, however, that the increase in the *normal juice factor* is not proportionate to the increase in juice extraction. As the juice extraction increases, the increase in the *normal juice factor* per unit increase in juice extraction increases. In other words, the difference between the *normal juice factor* corresponding to 80 per cent juice extraction, and that corresponding to 60 per cent juice extraction is less than the difference between the *normal juice factor* corresponding to 100 per cent juice extraction and that corresponding to 80 per cent juice extraction.

It follows from the preceding calculation based on a uniform ratio of variation that if the *normal juice factor* corresponding to 60 per cent juice extraction is 97.5 that corresponding to 80 per cent juice extraction will be less than 98.75 and that corresponding to 40 per cent juice extraction will be greater than 96.25. In other words, the actual variation in the *normal juice factor* produced by the possible variation in the juice extraction obtained by the crusher is even less than a calculation based on a constant ratio of variation would indicate.

It is obvious, since the juice first extracted is of higher density than the average density of the normal juice, that the juice contained in the cane is not of uniform density.

Noel Deerr analyzed separately the pith, nodes, and rind of the cane. He found the node juice to be of about the same density as the rind juice. The density of the pith juice was found to be considerably higher than that of the mode and rind juice. Table III is a tabulation of the analyses obtained by Noel Deerr as given on page 186 of "Cane Sugar" (Revised Edition):

When cane is subjected to pressure, the thin-walled fragile cells of the pith are ruptured and give up their juice first. The juice contained in the tough thick-walled cells of the nodes and rind is expressed more slowly and under greater pressure. Hence the crusher (or first expressed) juice consists very largely of pith juice. There is, however, some admixture of juice from the nodes and rind because it is obviously impossible to express any portion of the pith juice without the rupture of some of the cells of the nodes and rind.

It may be logically inferred, therefore, that as the pressure, and hence the juice extraction, decreases, the density of the first expressed juice approaches but never quite equals the density of the pith juice. This is equivalent to saying that as the juice extraction approaches zero, the *normal juice factor* approaches, but never reaches the ratio of the Brix of the normal juice to the Brix of the pith juice.

Hence, from Table III the average minimum and maximum limits of variation of the *normal juice factor* corresponding to the average minimum and maximum limits of juice extraction would be:

	Minimum limit	*Maximum limit.*
Juice extracted percentage of normal juice.....	0	100.0
Corresponding normal juice factor.....	97.66	100.0

Since the pith contains from 60 to 80 per cent of the total juice in the cane, it follows that below 60 per cent juice extraction, the crusher juice will contain such a large proportion of pith juice that the *normal juice factor* will be practically constant and very close to its minimum limit.

TABLE III.—*Showing analyses of pith, nodes, and rind of the cane according to Deerr.*

Items.	Rose Bamboo	Yellow Caledonia	Lahaina	Lahaina	Yellow Caledonia	True average recalculated
1. Percentage of fiber in cane	12.88	15.09	13.75	11.60	15.55	13.77
Normal juice:						
2. Percentage of solids	16.87	18.52	18.59	22.72	21.22	19.59
3. Purity	90.22	82.94	82.79	90.32	85.71	86.40
Pith juice:						
4. Pith juice percentage of normal juice	78.35	71.24	75.93	66.31	72.52	72.85
5. Percentage of solids	17.33	19.17	19.37	23.43	21.49	20.06
6. Normal juice factor for pith juice	97.35	96.61	95.97	96.97	98.74	97.66
Nodes and rind juice:						
7. Nodes and rind juice percentage of normal juice	21.65	28.76	24.07	33.69	27.48	27.15
8. Percentage of solids	15.22	17.31	16.11	21.37	20.51	18.43
9. Normal juice factor of nodes and rind juice	110.84	106.99	115.39	106.32	103.46	106.29

In order to observe the actual effect of an increase in the juice extraction upon the *normal juice factor*, a dry milling test could be made and the *normal juice factor* calculated: (a) from the Brix of the crusher juice alone; (b) from the average Brix of the combined juice of the crusher and first mill; (c) from the average Brix of the combined juice of the crusher and first and second mills; (d) from the average Brix of the combined juice of crusher and first, second, and third mills; (e) from the average Brix of the combined, or mixed juice of the entire train of mills.

From the record of a complete dry milling test found on page 38 of "Methods of Chemical Control" (Hawaiian Chemists' Association, 1916) is quoted the following data:

Juice obtained from:	*Brix*	*Juice percentage in cane*
Crusher+Mill I	21.3	67.0
Mill II	20.9	4.3
Mill III	21.1	3.1
Mill IV	20.7	1.2
Normal juice	20.7	88.7

From the above data the effect of successive increases in juice extraction upon the *normal juice factor* is calculated as follows:

Juice obtained from:	*Average Brix*	*Juice extracted percentage normal juice*	*Normal juice factor*
Crusher+Mill I	21.300	75.53	97.183
Crusher+Mills I and II	21.276	80.38	97.293
Crusher+Mills I, II and III	21.269	83.88	97.325
Crusher+Mills I, II, III, and IV	21.260	85.23	97.366

It will be observed that an increase in juice extraction from 75.54 per cent to 85.23 per cent, a total increase of almost 10 per cent in juice extraction increased the *normal juice factor* by no more than 0.183.

It is also possible from the data available for the mill run already used to illustrate the effect of variations in trash deduction, to calculate what the Brix of the mixed juice would have been if no maceration had been used, and what total percentage of the normal juice was extracted, as well as what percentage of the normal juice was extracted by the crusher. Thus there can be obtained not only the *normal juice factor* corresponding to the juice extraction actually obtained by the crusher but also the *normal juice factor* corresponding to the total juice extraction obtained by the entire train of mills.

In these calculations, which follow, no deduction is made for trash and the percentage of fiber in cane is calculated indirectly from the quantity of maceration applied. A correct calculation of the juice extraction would not be obtained if a trash deduction were made.

Take the same milling results as were used to illustrate the effect of variations in the trash deduction upon the *normal juice factor*. During this last day's run, which extended over a period of four hours, from the average analysis of samples

of the bagasse from the crusher and of the juice from the first mill taken at intervals of one hour the results shown in Tables IV and V are obtained:

TABLE IV.—*Juice extraction obtained by crusher and corresponding normal juice factor.*

	Item.	How obtained.	Percentage.
1.	Average A. Purity of first mill juice	analysis	83.4
2.	Average percentage of polarization of crusher bagasse	analysis	6.08
3.	Average percentage of soluble solids in crusher bagasse	(2) ÷ (1)	7.12
4.	Average percentage of moisture in crusher bagasse	analysis	54.7
5.	Average percentage of fiber in crusher bagasse	100–((3)+(4))	38.18
6.	Average percentage of fiber in gross cane (including trash)	See item (14), Table I.	13.324
7.	Crusher bagasse percentage of gross cane	(6) ÷ (5)	34.887
8.	Normal juice percentage of gross cane	100—(6)	86.676
9.	Moisture in crusher bagasse percentage of cane	(4) × (7)	19.083
10.	Soluble solids in crusher bagasse percentage of cane	(3) × (7)	2.484
11.	Normal juice in bagasse percentage of cane	(9)+(10)	21.567
12.	Normal juice extracted by crusher percentage of cane	(8)—(11)	65.109
13.	Percentage of normal juice extracted by crusher	(12) ÷ (8)	75.118
14.	Brix (percentage of soluble solids) of crusher juice	analysis	22.29
15.	Brix (percentage of soluble solids) of normal juice	See item (21), Table I.	21.715
16.	Soluble solids in crusher juice percentage of normal juice	(14) × (13)	16.743
17.	Soluble solids in crusher bagasse percentage of normal juice	(15)—(16)	4.972
18.	Residual juice in crusher bagasse percentage of normal juice	100—(13)	24.886
19.	Brix (percentage of soluble solids) of residual juice in crusher bagasse	(17) ÷ (18)	19.577
20.	Normal juice factor	See item (23), Table I.	97.42

TABLE V.—*Total juice extraction obtained by entire train of mills and corresponding normal juice factor.*

	Item.	*Percentage.*
21.	Brix mixed juice	14.83
22.	Brix normal juice	21.715
23.	Dilution of mixed juice percentage of normal juice	46.426
24.	Normal juice percentage of cane	86.676
25.	Mixed juice percentage of cane	122.006
26.	Dilution mixed juice percentage of cane	40.240
27.	Normal juice extracted percentage of cane	81.766
28.	Normal juice extracted percentage of total normal juice	94.335
29.	Mixed juice percentage of normal juice extracted	149.214
30.	Brix of normal juice extracted	22.128
31.	Normal juice factor with juice extraction of 94.335 per cent	98.134
32.	Soluble solids extracted percentage of normal juice	20.874
33.	Soluble solids unextracted percentage of normal juice	0.841
34.	Unextracted juice percentage of total normal juice	5.665
35.	Brix of unextracted portion of normal juice	14.846

From the calculations in Tables IV and V, it will be observed that the following relations obtain:

When the juice extraction is	75.118	94.335	100.000
The normal juice factor is	97.420	98.134	100.000
The Brix of the normal juice is	21.715	21.715	21.715
The Brix of the extracted juice is	22.290	22.128	21.715
The Brix of the unextracted juice is	19.577	14.846	0.000
Unextracted juice percentage of total normal juice is	24.882	5.665	0.000

The limit of the *normal juice factor* as the juice extraction approaches zero may be approximated from the three values of the *normal juice factor* already

determined. The relations shown in Table VI obtain between the values of the *normal juice factor* already determined and the corresponding juice extractions.

TABLE VI.—*Showing relations between value of the normal juice factor and juice extraction.*

As the juice extraction decreases		The normal juice factor decreases		Decrease in juice extraction.	Decrease in normal juice factor.
From	To	From	To		
100.000	94.335	100.000	98.134	5.665	1.866
94.335	75.118	98.134	97.420	19.217	0.714

From this consideration the following computation is possible:

Now let x = a juice extraction below 75.118
and y = the normal juice factor corresponding to the juice extraction x
Then $75.118 - x$ = decrease in juice extraction from 75.118 to x
and $97.42 - y$ = decrease in normal juice factor from 97.42 to y.
Let it be assumed that if x is so chosen that

$$(1) \quad \frac{5.665}{19.217} = \frac{19.217}{75.118 - x}$$

Then it will also be true that:

$$(2) \quad \frac{1.866}{0.714} = \frac{0.714}{97.42 - y}$$

Solving equations (1) and (2)

$y = 97.147$
When $x = 9.929$

Since a juice extraction of 9.929 per cent is much lower than would ever actually be obtained by a crusher, it is unnecessary to seek the *normal juice factor* corresponding to a lower juice extraction.

From the four values of the *normal juice factor* now determined it is possible to approximate the graph of the *normal juice factor* as the juice extraction varies from zero to 100 per cent. The graph follows in Figure 1.

From Figure 1, the following series of approximate values of the *normal juice factor* corresponding to various juice extractions is obtained.

Juice extracted percentage of normal juice.	*Corresponding normal juice factor.*
40.0	97.15
50.0	97.17
60.0	97.22
65.0	97.27
70.0	97.34
75.0	97.42
80.0	97.52

From the foregoing, it will be observed that, within the limits of variation in the juice extraction actually obtainable by a crusher or by a crusher and first mill combined, the effect of variations in the juice extraction upon the *normal juice factor* is negligible.

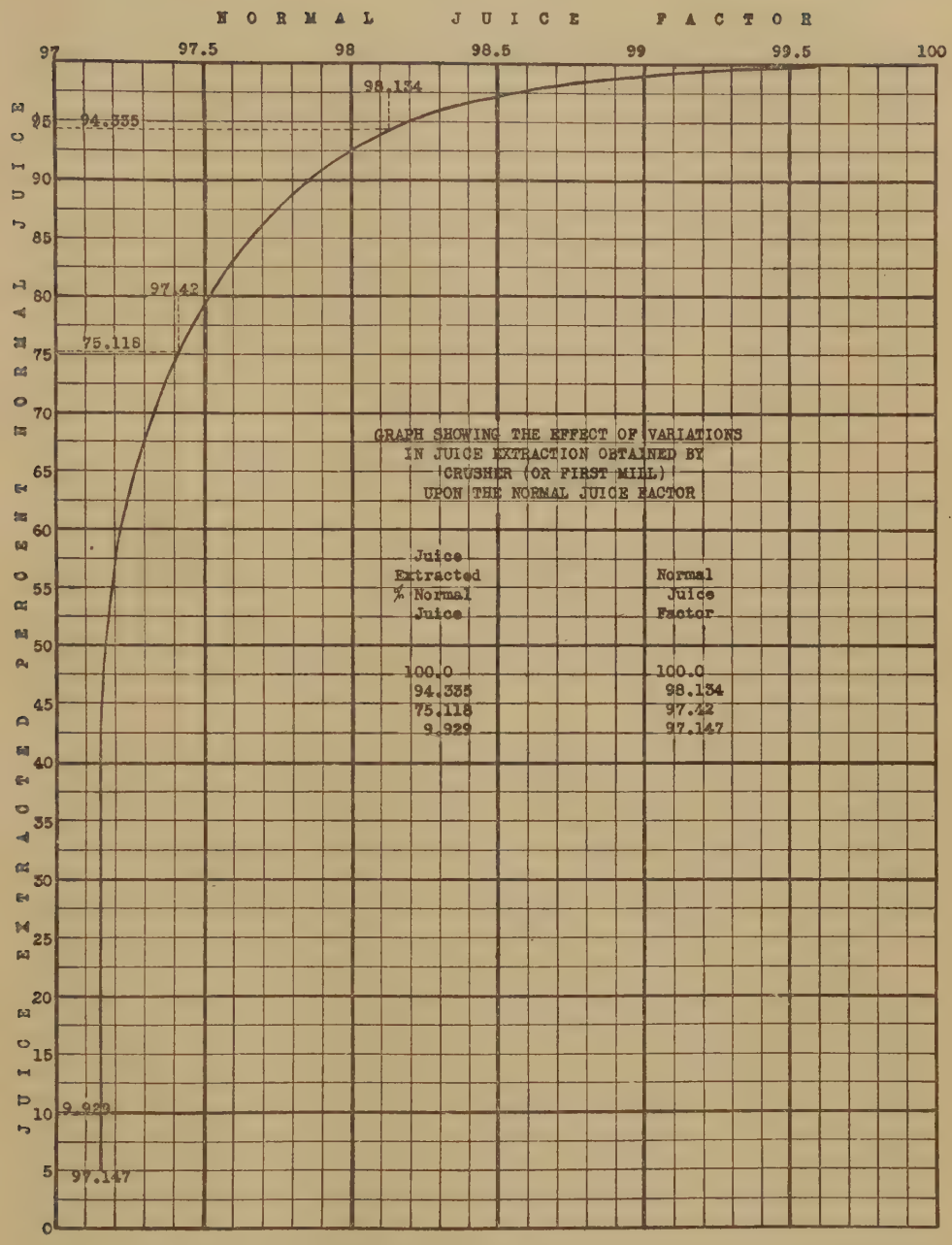
NORMAL JUICE FACTOR
97
97.5
98
98.5
99
99.5
100
JUICE EXTRACTED PERCENT NORMAL JUICE
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
98.134
94.335
97.42
75.118
9.929
97.147
GRAPH SHOWING THE EFFECT OF VARIATIONS
IN JUICE EXTRACTION OBTAINED BY
CRUSHER (OR FIRST MILL)
UPON THE NORMAL JUICE FACTOR
Juice Extracted % Normal Juice
Normal Juice Factor
100.0 100.0
94.335 98.134
75.118 97.42
9.929 97.147

Fig. 1

EFFECT OF VARIATION IN COMPOSITION OF THE CANE UPON THE NORMAL JUICE FACTOR

The writer has been unable to observe that such variation in the composition of the cane as has come within the range of his observation produced any appreciable variation in the *normal juice factor*. He has not, however, accumulated sufficient experimental data to venture any definite assertion as to the precise extent of the variation in the *normal juice factor* which might possibly be produced by extreme variations in the composition of the cane. It is possible, however, to arrive at certain general conclusions as to the possible effect of variations in the composition of the cane upon the *normal juice factor*.

From the standpoint of their possible effect upon the *normal juice factor*, variations in the composition of the cane may be subdivided into the following classes:

1. Variations in the purity of the normal juice.
2. Variations in the Brix of the normal juice.
3. Variations in the percentage of fiber in cane.
4. Variations in the relative quantities of node and rind juice and of pith juice.
5. Variations in the ratio of Brix of node and rind juice to Brix of pith juice.

Effect of variations in purity of normal juice upon the normal juice factor.—It is obvious, since the *normal juice factor* is the ratio of the Brix of the whole normal juice to the Brix of a part of the normal juice, that variations in the purity of the normal juice would not affect the *normal juice factor*. Purity is, by definition, the ratio of percentage of sucrose to Brix, and this ratio is in no way involved in the *normal juice factor*.

Effect of variations in Brix of normal juice upon the normal juice factor.—It is obvious that variations in the average Brix of the whole normal juice would of itself have no effect, whatever, upon the *normal juice factor*. Variations in the *normal juice factor* would occur only when there was (1) a variation in the ratio of the Brix of the node and rind juice to the Brix of pith juice, or (2) a variation in the relative proportions of node and rind juice and of pith juice contained in the cane. These two cases will be considered separately.

Effect of variations in the percentage of fiber in cane upon the normal juice factor.—There are two respects in which variation in the percentage of fiber in cane might affect the *normal juice factor:* First, as the percentage of fiber in cane increases, the juice extraction, other conditions being equal, decreases. Hence, as the percentage of fiber in cane increases, the *normal juice factor* should tend to decrease. Second, Noel Deerr observes on page 187 of "Cane Sugar" (Revised Edition) "as a general rule that a high percentage of fiber is associated with a high proportion of rind tissue." This means that as a general rule, as the percentage of fiber in cane increases the percentage of node and rind juice in the cane also increases. It follows that, other conditions being equal, as the percentage of fiber in cane increases the node and rind juice extracted percentage of total juice extracted should increase. Hence, since the Brix of the node and rind juice is less than the Brix of the normal juice, while the Brix of the pith juice is greater than that of the normal juice, it also follows that as the percentage of fiber in cane increases as the average Brix of the extracted juice tends to decrease; or, in other words, the *normal juice factor* tends to increase.

There are, therefore, with respect to the *normal juice factor*, two opposite tendencies as the percentage of fiber in cane increases: First, the *normal juice factor* tends to decrease because the juice extraction decreases. Second, the *normal juice factor* tends to increase because the proportion of low Brix node and rind juice contained in the cane increases. It will be observed that these two opposite tendencies should very largely neutralize each other so that the net effect of variations in the percentage of fiber in cane upon the *normal juice factor* should be practically zero.

And in any case, even though one of these two opposite tendencies should predominate, the actual effect upon the *normal juice factor* would not be great. It has already been shown that below 80 per cent juice extraction, even large variations in the juice extraction do not appreciably affect the *normal juice factor*. And the difference in Brix between the node and rind juice and the internode juice is not great enough for any possible difference in the relative proportions of these two juices extracted by the crusher to have any large effect upon the *normal juice factor*.

It is essential, however, that the percentage of fiber in cane be accurately determined for errors in the determination of the percentage of fiber in cane will result in errors in the calculation of the Brix of the normal juice, which in turn will produce abnormal variations in the calculated *normal juice factor*.

Effect of variations in the relative quantities of node and rind juice and of pith juice upon the normal juice factor.—Let it be assumed that the ratio of the Brix of the node and rind juice to the Brix of the pith juice remains constant in order to consider the possible effect upon the *normal juice factor* of variations in the relative proportions of node and rind juice and of pith juice. As has already been shown, the first expressed juice consists of a very large proportion of pith juice mingled with a small proportion of node and rind juice. Other conditions being equal, it might be expected that as the ratio of node and rind juice contained in the cane to total normal juice increased, so also would the ratio of node and rind juice contained in the first expressed juice to total first expressed juice increase. This would mean that, as the ratio of node and rind juice contained in the cane to total normal juice increased, the *normal juice factor* would also increase. As a general rule, however, an increase in the ratio of node and rind juice contained in the cane to total normal juice is coincident with a corresponding increase in the percentage of fiber in cane, which would of itself tend to reduce the total juice extraction obtained by the crusher. Hence, because of this, and because of the difficulty of expressing the node and rind juice as compared with the pith juice, the juice extraction obtained by the crusher tends to decrease as the proportion of node and rind juice contained in the cane increases. But a decrease in juice extraction, other conditions being equal, has a tendency to decrease the *normal juice factor*. There are, just as in the case of variations in the percentage of fiber in cane, two opposite tendencies; one, toward an increase in the *normal juice factor*, and the other toward a decrease in the *normal juice factor*. The net effect, therefore, upon the *normal juice factor* of variations in the relative proportions of node and rind juice and of pith juice is likely to be extremely small.

Effect of variations in the ratio of Brix of node and rind juice to brix of pith juice upon the normal juice factor.—If the relative proportions of node and rind juice and of pith juice contained in the first expressed juice be assumed to remain

constant, it is obvious that any variation in the ratio of the Brix of the node and rind juice to the Brix of the pith juice would produce a corresponding variation in the *normal juice factor*. As the difference in Brix between the node and rind juice and the pith juice decreases, the *normal juice factor* would increase, approaching 100 as a limit as the Brix of the node and rind juice approaches the Brix of the pith juice as a limit. The limits of variation in the ratio of the Brix of the node and rind juice to the Brix of the pith juice are, however, so narrow, that the actual effect of such variations upon the *normal juice factor* is quite small.

EFFECT OF CERTAIN SPECIAL OPERATING CONDITIONS UPON THE NORMAL JUICE FACTOR

Two special operating conditions may be mentioned as likely to affect the *normal juice factor*.

Effect of disintegration of the cane by a shredder.—It might be expected that, other conditions being equal, the disintegration of the cane by a shredder prior to passage through the crusher would result in a somewhat higher *normal juice factor* than would be the case if no shredder were used. It stands to reason that the disintegration of the cane would result in the rupture of a larger proportion of the cells of the nodes and rind, and that the first expressed juice would, therefore, contain a larger proportion of the low density node and rind juice. Such being the case, the *normal juice factor* would be higher than where no shredder is used. Unfortunately, the writer has no definite data on this point.

Effect of fluming the cane upon the normal juice factor.—In like manner, it might be expected that where the cane is flumed to the cane carrier, the extraneous water adhering to the cane would so reduce the Brix of the first expressed juice as to produce an abnormally high *normal juice factor*. In some cases, the dilution might even be so great as to result in a *normal juice factor* above 100. A similar result might occur when the cane was drenched by a heavy shower immediately before being ground.

CONCLUSION

The writer presents this paper in the hope that it may arouse, among his fellow chemists, a general interest in the possibilities of the *normal juice factor* as a basis for closer laboratory control.

The *normal juice factor* is not a panacea for all the existing deficiencies in chemical control; neither is it fool-proof. But its intelligent use will make possible a material advance in the effectiveness of chemical control of cane sugar factories.

THE SOFT ROT OF PINEAPPLE IN THE PHILIPPINES AND OTHER COUNTRIES[1]

By Emiliano F. Roldan[2]
Of the Department of Plant Pathology

WITH TWO PLATES

INTRODUCTION

The soft rot of pineapple (*Ananas comosus* (L.) Merr. (*A. sativas* Schultes f.) is a serious disease new in the Philippines. Although it has been reported and studied in various important pineapple-growing countries, the first report of its occurrence in the Islands was made only recently by Ocfemia (1). The report was made from specimens submitted by Mr. Teodorico Reyes through Professor J. E. Higgins, Head of the Department of Agronomy of this College.

The large number of infected fruits submitted to the Plant Pathology Laboratory for study during the latter part of June, 1924, and the fact that the disease is reported to cause the stem-bleeding disease of coconut (*Cocos nucifera* L.) and the pineapple disease of sugar cane (*Saccharum officinarum* L.), suggested that the disease is of economic importance, inasmuch as both coconut and sugar cane are two of the major crops in the Philippines. The object of the present work was to determine whether or not the soft rot of pineapple in the Philippines is caused by *Thielaviopsis paradoxa* von Höhnel. The object of making this determination was to benefit by the control recommendations given for the disease, as this malady has been studied more or less extensively in various places.

THE DISEASE

HOSTS

Examination of soft rot infections on pineapple in the Philippines and isolation for the causal organism always gave a *Thielaviopsis*. Larsen (2) and Patterson, Charles, and Veighmeyer (3) report *Thielaviopsis paradoxa* von Höhnel as causing the soft rot of pineapple. *T. paradoxa* or its synonym *T. ethaceticus* Went has been described as causing the pineapple disease of sugar cane and the stem-bleeding-disease of coconut. In the early part of April, 1924, Dr. R. B. Espino, of the Department of Plant Physiology, and Dr. G. O. Ocfemia, of the Department of Plant Pathology, examined cases of the stem bleeding-disease of coconut due to *T. paradoxa* in the plantation of the Calamba Sugar Estate in Canlubang, Laguna. The disease is said not to be serious and is practically under control by means of tree surgery and carefully conducted sanitary measures. Larsen (2) has proven conclusively that the soft rot of pineapple and the pineapple disease of sugar cane in Hawaii are caused by the same organism *T. paradoxa*.

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[1] Experiment Station contribution No. 267.

[2] The writer wishes to thank Dr. G. O. Ocfemia, Acting Head, Department of Plant Pathology, for helpful suggestions during the work, and Professor J. E. Higgins, Head of the Department of Agronomy for the fruit materials used in experiments.

HISTORY, GEOGRAPHICAL DISTRIBUTION, AND ECONOMIC IMPORTANCE

Patterson, *et al.* (3), state that the soft rot of pineapple was first described by De Saynes who attributed the cause to *Sporoschisma paradoxa* in 1886. Saccardo described the same organism as *Chalara paradoxa* (De Seyn.) in 1892. Went, working on the soft rot of pineapple in Java, called the causal fungus *Thielaviopsis ethaceticus* in 1893. Von Höhnel found that *Chalara paradoxa* (De Seyn.) Sacc. and *Thielaviopsis ethaceticus* Went are identical and, in 1904, referred it to *T. paradoxa*. Smith (4) described, in 1903, the cause of the pineapple disease of sugar cane in Hawaii as *Thielaviopsis ethaceticus*. This author states that the pineapple disease of sugar cane occurs in Java, the West Indies, and in other sugar cane growing countries causing more or less serious losses. Tower (5) reported, in 1906, base rot of pineapple in Porto Rico, said to be caused by a *Thielaviopsis*. Stockdale (6) described, in 1907, the appearance of pineapple rot disease in West Indies, the symptoms of which are identical with the typical soft rot in that country. Cobb (7) reports the prevalence of the pineapple disease of sugar cane in Hawaii in 1909 and states that this disease is one of the worst troubles in growing pineapples in Jamaica and Florida. Petch (8), in 1910, found that *Thielaviopsis paradoxa* was present in India. It was often found on pineapples causing a destructive rot of fruit.

Larsen (2) in his studies of the soft rot of pineapple in Hawaii reports a loss of about 10 per cent in the field and in the canneries. The same author reports as high as 50 to 75 per cent of loss of pineapples in transit due to soft rot.

Vosbury and Winston (10) state that the decay of pineapples in transit due to the soft rot causes heavy losses. In the Philippines the disease is serious on fruits in storage and on piles of crowns, but is not serious in the field. No definite estimate of loss has been made.

It was reported in 1923 that seed cane deterioration caused losses in southern Georgia (11). *T. paradoxa* was isolated as one of the organisms associated with the rotting cane. The same report states that the same type of injury in Louisiana caused greater damage on canes than in the previous two years.

DESCRIPTION OF THE DISEASE

On fruits.—The first symptom of fruit infection is the presence of water-soaked lesions hardly distinguishable from the healthy portions of the fruit. Infection may start from bruises, wounds, and the scars which are left after the removal of the stem, suckers, or crowns. A watery rotting follows. A yellowish fluid may squirt out if infected fruits are pressed between the hands. At this stage black masses of spores develop from the injured portions of the fruits, followed by the general collapse of the tissues (1) (Plate I, fig. 1). Fruit infection is rapid in a moist and warm atmosphere.

On the crowns and leaves.—Infection of the crown starts at the base. The lesions progress inwards into the heart. The heart rots and the soft bases of the leaves may also rot. At this stage the leaves are loosened and may be easily pulled off the stem.

On the leaves, the infection starts at any point as water-soaked areas. In old cases, the points affected become depressed and sunken.

In infections on the crown and leaves masses of fungus spores are produced in abundance.

CAUSAL ORGANISM

The fungus was isolated by taking small portions of the inner tissues of fruits with young stages of infection by means of a flamed scalpel and plating these on sterilized corn meal in petri dishes. After 24 hours the fungus developed a greenish gray growth which turned dark green later (1). The writer produced 100 per cent pure growth in all isolations of the fungus. Transfers were made from the corn meal to various common culture media for cultural and morphological studies.

MORPHOLOGY

Mycelium.—The mycelium of the fungus is hyaline, granular, with a greenish tint, frequently branched and septate. It becomes ragged and thick walled with age. The breadth of the filaments ranges from 2.5 to 10.5 μ (Plate II, fig. 1).

Conidiophores.—The conidiophores are of two types. One bears macroconidia and the other bears microconidia. The conidiophores bearing macroconidia are more or less club-shaped, septate, hyaline and sometimes granular. The number of septa varies from one to three. The length measures from 21.96 to 73.20 μ. They produce from two to forty conidia in chains (Plate II, fig. 10).

The conidiophores bearing microconidia are hyaline or may be granular tinged with light green color. Their form is very characteristic. The basal portion is swollen but abruptly constricted at the point of attachment to the mycelium and tapers towards the apex presenting a candle-stick shape. The microconidiophores are septate. The septation varies from two to thirteen. The frequency of septation depends upon the length of conidiophores. The writer found that the conidiophores vary from 34.90 to 250.20 μ. The microconidiophores produce two types of microconidia, which form chains of from 2 to 75 (Plate II, figs. 2 and 7).

Both the macro- and the microconidiophores may be produced laterally from the same mycellium.

Macroconidia.—The macroconidia are light to dark brown, smooth, ovoid or ellipsoidal, having thick walls. The macroconidia are pushed up from the conidiophores when new spores are produced below and finally form chains, consisting of as many as forty spores. When the macroconidia are placed in nutrient media, they germinate within 24 hours. The size of the macroconidia ranges from $14.36 - 20.5 \times 9.15 - 14.90$ μ (Plate II, fig. 6).

Microconidia.—The microconidia are of two types, easily distinguished from each other on account of the size, form, and color. One is light brown and the other is hyaline. Both forms of microconidia are borne on the same kind of conidiophores.

The microconidia of light brown color are barrel-shaped, or ovoid, rarely cylindrical, with thick wall, varying from $9.32 - 18.96 \times 4 - 6.15$ μ (Plate II, fig. 4).

The hyaline microconidia are cylindrical with thin wall, varying in size from $8.32 - 10 \times 3.66 - 4.02$ μ (Plate II, fig. 3).

Both types of microconidia are formed in the same manner. They develop inside the hyphal cell of the conidiophores and are ejected one after the other, forming chains (Plate II, figs. 2 and 3). The hyaline microconidia are produced

more profusely and in chains of from 2 to 75 while the colored microconidia are from 2 to 50, in a chain. The microconidia when placed in any suitable culture media germinate readily after a few hours.

In the cultural and morphological studies of the fungus no other types of fruiting bodies were observed other than the imperfect or conidial stage. According to Larsen (2) the existence of the perfect stage of the *Thielaviopsis* is an unsettled question, while Massee (11) contends that the perfect stage of *Thielaviopsis* is *Thrichosphaera sacchari* Masse. His contention, however, lacking proof, is not supported by other investigators. Patterson *et al* (3) state that in addition to the existence of macrospores and microspores the pycnidial stage was observed. Larsen (2) does not hold with this view for no proof has been given that there is connection between the pycnidial and the conidial forms of *Thielaviopsis*. According to Larsen, Cobb (2) observed a growth of aërial microconidia on diseased tissue of pineapple. These conidia differ from ordinary microconidia in that they appear readily on the affected tissue which has been exposed for about twelve hours and are more profuse in their formation than the ordinary microconidia.

CULTURAL STUDIES

The cultural studies of the fungus were made by growing it on various culture media such as potato-dextrose agar, oatmeal agar, pineapple decoction, Lima bean juice agar, potato cylinders, corn meal, pineapple fruit cylinders, and steamed pineapple leaf. On all of these media and substrata the fungus showed comparatively good growth. The cultural feature of the fungus on the various culture media did not differ greatly. The predominant snowy white growth on the cultures twenty-four hours old, turning to grayish green and dark green as they became older, was the conspicuous character of the fungus. The production of microconidia in cultures twenty-four to forty-eight hours old, followed later by the formation of macroconidia, was observed to take place in all cultures. The fungus showed such rapidity of growth in all cultures, that the entire surface of the substrata was covered with the fungus growth after four days. The fungus however showed a tendency to produce less profuse growth on steamed pineapple leaf than on the other media. The fungus was not found to produce structures indicating the perfect stage during the course of the cultural studies, nor did the writer observe any pycnidial form.

RELATION OF THE FUNGUS TO SUNLIGHT

In connection with the cultural studies, experiments were conducted to find the effect of light on the fungus. In these experiments, potato-dextrose agar slants in test tubes were inoculated with the fungus spores taken from fresh cultures. Two sets of the test tubes were exposed to sunlight during the whole day and another set was placed in darkness in the laboratory. One of the sets exposed to sunlight was placed in a beaker under running water from the faucet so as to keep the temperature in the tubes low without interfering with the light. The other set of test tubes was exposed to full sunlight without immersion in running water. To determine the range of temperature in each set, thermometers were inserted in test tubes in which were potato-dextrose-agar slants, and one placed with every set. The ranges of temperatures were recorded and are as follows: Set in darkness, 25 – 28° C.; set submerged in running water, 28 – 32° C.; and the set exposed to full sunlight, 32 – 44° C. After twenty-four hours, growth

was observed in the test tubes placed in darkness and in test tubes submerged in running water, but none in the test tubes that were exposed to sunlight without reducing the temperature. Observations were made on the following days but the same condition was noted. It is interesting to note in this connection that Larsen (2) proved that *T. paradoxa* von Höhnel is very sensitive to light. He does not mention, however, whether or not temperature was controlled in his experiments; and temperature has a very decided effect on the fungus. The writer believes that it is not the light alone that has so decided an influence and inhibitory effect on the growth of the fungus, but that the influence is strengthened by the high temperature (44° C.) generated during exposure to the sun.

PATHOGENICITY

Larsen (2) reported the inoculation of pineapple fruits with *T. paradoxa.* This author conclusively proved that the fungus is capable of infecting pineapple fruits with and without the help of wounds. He also proved that the fungus can affect green pineapple quite as readily as the ripe.

Experiments on the pathogenicity of the fungus causing soft rot of pineapple fruits in the Philippines showed that the fungus does not only affect the pineapple but other fruits, such as banana (*Musa sapientum* L.) and mango (*Mangifera indica* L.), and also sugar cane (*Saccharum officinarum* L.). The inoculation series, each with two checks, were made on each kind of host plants used. All parts to be inoculated were carefully disinfected with 1 to 1000 mercuric bichloride solution and then washed thoroughly with sterile water. The inoculum was taken from fresh cultures on potato-dextrose agar. Spores and hyphae were applied to the wounds made on the hosts. The checks were also treated in the same manner using sterile agar for inoculum. The inoculated fruits and stems, as well as the checks, were placed in damp chambers. From two to five days after inoculation, the inoculated fruits and stems, with the exception of the fruits of avocado (*Persea americana* Mill), and the checks showed the characteristic signs of infection. After a few days, more of the dark green fungus growth developed and became more and more distinct at the points of infection. The results obtained in the inoculation experiments point out that the fungus causing soft rot of pineapple fruits in the Philippines is pathogenic not only on pineapple but also on other fruits and on sugar cane.

SPORE GERMINATION

Spore germination experiments were conducted by placing spores in hanging drops of sterile liquified potato-dextrose agar on cover slips that were previously flamed over an alcohol lamp. The sterile drops were inoculated with the three different kinds of spores taken from young cultures. Then the cover slips with the inoculated drops of culture medium were inverted over hanging-drop slides and fastened with vaseline. Six hanging drop cultures were prepared and examined closely for the germination of spores. In the course of observation it was found that a large number of both the hyaline and colored microconidia germinate after five to eight hours, and the macroconidia germinate after twenty-four hours. The germination of both forms of microconidia gives rise to the formation of hyaline germ tubes, at the ends, a little below the ends or at the middle of the cell. In most cases the germ tubes developed readily into conidiophores producing microconidia in chains (Plate II, figs. 8 and 9). When macroconidia germinate

they produce a hyaline germ tube with swollen base (Plate II, fig. 5). The germ tubes were found to occur only at the middle of the cell and not to produce conidia immediately as the microconidia do in germination. Furthermore the formation of macroconidia takes place and develops from conidiophores borne on the mycelium (Plate II, fig. 10). Authors do not agree as to this difference in time in germination and formation of micro- and macroconidia. Some claim that both micro- and macroconidia germinate and develop immediately at the same time, others are of the opinion that the microconidia germinate and develop more readily than the macroconidia. It was found in experiments here reported that microconidia germinate and form more readily than macroconidia. What conditions govern this difference in time for germination and production of micro- and macroconidia obtained by investigators can not be definitely stated. The little difference in time of germination between the micro- and macroconidia found by the writer can not be regarded as time spent in dormant stage by the macroconidia before they germinate.

TAXONOMY

The fungus causing soft rot of pineapple and pineapple disease of sugar cane in Java was first ascribed to *Thielaviopsis ethaceticus* by Went (12). Later these two diseases were attributed definitely to *Thielaviopsis paradoxa* von Höhnel (13). According to Larsen (2) the soft rot of pineapple fruit in Hawaii is caused by *T. paradoxa* von Höhnel, which is described as follows: The fungus produces two forms of spores, known as macroconidia and microconidia. The macroconidia are dark colored ovate, possessing thick wall measuring from 16–19 $\times$ 10–12 μ. They are arranged in chains of from four to twenty spores at the end of the conidiophores. The microconidia are of two types. One is a thin-walled colorless spore, cylindric in shape, measuring from $10 - 15 \times 3.5 - 5\ \mu$. The second type is darker in color, more ovate in form and provided with thicker wall. The two types of microconidia are borne in chains at the end of special branches or conidiophores. The conidiophores bearing microconidia differ from those bearing macroconidia in being swollen at the base. They are constricted at their point of attachment to the mycelium, then become more or less swollen and gradually taper toward the spore-bearing end. The macroconidiophores are usually the same thickness throughout the entire length.

The fungus causing soft rot of pineapple in the Philippines produces macroconidia, microconidia, and conidiophores similar to those that are produced by *T. paradoxa* von Höhnel. The macroconidia are smooth ovoid, dark brown in color, with thick wall, varying from $14.36 - 20.50 \times 9.15 - 14.90\ \mu$ The two types of microconidia differ slightly in size. The brown colored ones, which are barrel-shaped, ovoid, and rarely cylindrical, vary from $9.32 - 18.96 \times 4 - 6.16\ \mu$. The hyaline microconidia are invariably cylindrical and are from $8.32 - 10 \times 3.66 - 4.02\ \mu$. It will be noted that the *Thielaviopsis* occurring in the Philippines closely resembles *T. paradoxa*. Although the Philippine *Thielaviopsis* shows slightly larger spores, yet the difference is not sufficient to warrant the separation into a new species. The writer, therefore, concludes that the fungus causing soft rot of pineapple in the Philippines is identical with the *Thielaviopsis paradoxa* von Höhnel causing soft rot of pineapple and pineapple disease of sugar cane in Java and in the Hawaiian Islands.

LIFE HISTORY OF THE CAUSAL ORGANISM IN RELATION TO THE PRODUCTION OF DISEASE

Lesions are common on leaves of pineapples under field conditions. The diseased areas appear as dark green and sunken patches causing but little damage to the plants in the field. The diseased areas are found on any part of the leaf, but more frequently at the base. Examination of the lesions under the microscope often show macroconidia. This condition is persistent under field environment. Larsen (2) states that during its saprophytic stage *Thielaviopsis* is able to live in the soil on dead roots and leaf trash or ripe fruit of pineapple, banana, and mango. It is probable that the fungus tides over adverse conditions by the production of macroconidia which are lodged and protected in the leaf tissues of pineapple or in trash of some susceptible hosts. The presence of viable spores in this condition in the soil serves as source of inoculum. The spores may be disseminated by insects, wind, or man, and dropped into crevices in the fruit. Very often the disease breaks out while the fruits are in storage or in transit. Since the fungus is able to force its way into the fruit, with or without injuries, infection may occur at any time under favorable conditions. This may be the means by which an outbreak of the disease may be traced.

CONTROL MEASURES

In order to control the disease the essential point to consider is the source of infection. Since it has been known that the macrospores of the fungus are able to live for some time in the lesions of the leaves and on the trash of the hosts, it is advisable that any part of the host suspected to be infected should be collected and either plowed under or burned. The infected parts should never be piled with manure or compost as under these conditions the fungus can exist and produce abundant spores for dissemination in all directions. Only selected slips which are entirely free from infection should be planted. Great care should be exercised in handling the fruit so as to avoid wounding or bruising as injuries so caused are the chief avenues for the spores to start infection. The bracts and the stem should not be pulled off but should be cut off a little distance from the fruit. Larsen (2) states that in severe cases exposing the slips in the sun for one week before planting gives a reduction of 90 per cent of infection. Low stripping gives a reduction of 57 per cent over high stripping, and dipping in Bordeaux mixture gave a decrease of 50 per cent. Patterson *et al* (3) in their experiments on fumigation conclusively proved that formaldehyde gas is an efficient means of controlling *T. paradoxa*. The quantity of gas generated from 1200 or 1300 cc. of formalin per 20 cubic meters (1000 cubic feet) of air space is reported fatal to the fungus when exposed for 30 minutes or more, under varying degrees of temperature, ranging from 18° to 29° C. (65 to 80° F.) with fairly constant humidity of 38 per cent. Higgins (14) in his preliminary experiments with formaldehyde gas for checking pineapple rot has demonstrated its advantage as a preventive measure.

It is advisable not to intercrop coconut and pineapple, alternate sugar cane and pineapple or *vice versa*, since these three crops have been proven highly susceptible to the attack of *Thielaviopsis paradoxa.*

Doctor Espino of the Department of Plant Physiology and in charge of the course on coconut in the Department of Agronomy of this College says that the

occurrence of *Thielaviopsis paradoxa* on the pineapple in the Philippines suggests the undesirability of interplanting it with coconuts for the following reasons:

(1) Pineapple prefers plenty of sunshine and this condition is not obtainable in old coconut plantations.

(2) Pineapple may be destroyed by nuts that fall, and the prickly varieties make gathering of the nuts on the ground rather difficult.

(3) Pineapple is said to exhaust soil fertility.

(4) The organism causing soft rot of pineapple attacks the coconut, producing the stem-bleeding disease.

DISCUSSION

From the results, the writer concludes that *Thielaviopsis paradoxa* von Höhnel, described as causing pineapple rot and pineapple disease of sugar cane in Java and in the Hawaiian Islands, is the cause of the pineapple rot in the Philippines. The bleeding disease of coconut which occurs in Ceylon and which recently broke out in the Philippines is believed to be due to *T. paradoxa*. The Philippine *Thielaviopsis* appears to be identical, morphologically, with that of *T. paradoxa* von Höhnel. The Philippine strain shows a slight difference in size of spores from that of *T. paradoxa* in Hawaii. This difference, however, may be attributed to differences in climatic or other environmental conditions. The cultural studies of the fungus did not show the formation of the perfect stage nor any other form of spores except the conidial stage. High temperature generated by exposure to the sun inhibits the germination of spores. Artificial infection shows that the *Thielaviopsis* occurring in the Philippines is pathogenic not only to pineapple but also to mango, banana, and sugar cane. As regards varietal susceptibility, the writer has not conducted experiments on the degree of susceptibility of the different varieties of pineapples in culture at the College of Agriculture. Cobb (7) states that on pineapple *T. paradoxa* is dangerous to certain varieties. He considers that Smooth Cayenne is the most susceptible. In the Philippines, the writer observes that the disease is found to be serious on both the Spanish and on Smooth Cayenne varieties.

SUMMARY

The results may be summarized as follows:

(1) The soft rot of pineapple is a new disease in the Philippines.

(2) The disease is destructive to fruits in storage and to piles of slips when conditions are favorable. The disease, however, has not been found to cause much damage in the field, as yet.

(3) The fungus responsible for the pineapple rot in the Philippines is identical with *Thielaviopsis paradoxa* von Höhnel, the cause of the pineapple rot and pineapple disease of sugar cane in Java, and in the Hawaiian Islands, and the coconut stem-bleeding disease in Ceylon.

(4) The soft rot of pineapple, pineapple disease of sugar cane, and coconut stem-bleeding disease caused by *T. paradoxa* are present in Hawaii, Java, West Indies, India, Ceylon, Southern United States, and the Philippines.

(5) The *Thielaviopsis* occurring in the Philippines is pathogenic on banana, mango, and sugar cane.

(6) The disease may be controlled chiefly by avoiding injuries and collecting and destroying suspected hosts infected with fungus and by handling the fruits carefully in order to avoid formation of bruises, scars, and wounds.

(7) The fungus is able to force its way into fruits with or without wounds if conditions are favorable.

(8) No test was made on varietal susceptibility of pineapple in the Philippines.

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ILLUSTRATIONS

Plate I

Fig. 1. Pineapple fruit showing infection of soft rot disease. Note the dark colored portion around the points (x) covered with fungus growth.

" 2. Section of sugar cane stem showing infection, at points (a), with pineapple disease produced by artificial inoculation.

Plate II

Fig. 1. Mycelium of *Thielaviopsis paradoxa*.

" 2. Conidiophores bearing colored microconidia in chains.

" 3. Group of hyaline microconidia.

" 4. Group of colored microconidia.

" 5. Germinating macroconidia showing germ tubes with swollen bases. Note the peculiar position of the germ tubes characteristic of this fungus.

" 6. Group of macroconidia.

" 7. Conidiophores bearing microconidia in chains.

" 8. Germinating hyaline microconidia. One shows immediate formation of microconidia.

" 9. Germinating colored microconidia. One shows immediate formation of microconidia.

" 10. Conidiophores developed from mycelium and are producing chains of macroconidia.

1

2

PLATE I

PLATE II

WEATHER OBSERVATIONS AT LOS BAÑOS 1916-1923[1]

By Roman P. Estioko[2]
Of the Department of Plant Physiology

WITH TWO CHARTS

Chart I in this paper shows in degrees Centigrade the monthly maximum and minimum temperature extremes at the College of Agriculture, Los Baños, from 1916-1923. Chart II gives in millimeters the rainfall at the same place.

Temperature (Chart I).—The highest monthly maximum temperature within this period was 33.2° C. and the lowest 24° C. The highest was obtained in May, 1919, and the lowest in January, 1918. The highest minimum temperature recorded was 25.5° C. and the lowest, 21° C. The highest recorded was obtained in February, 1918, and the lowest in January, 1919.

Examination of the chart shows that the temperature reaches its maximum in May. After this month it drops gradually until January, when it starts to rise again.

In the annual temperature for the eight-year period, Chart I indicates a range of 1.4° C. between the lowest and the highest maximum; this is a low range. The highest annual maximum temperature was 29.2° C. and was obtained in 1922. The lowest was 27.8° C. and was obtained in 1921. The highest minimum was 23.7° C. and was obtained in 1916; the lowest, 22.6° C., was obtained in 1923.

The weather records obtained by the Weather Bureau[3] at the neighboring towns of Santa Cruz, Laguna; Manila, Rizal; and Batangas, Batangas, show that at Santa Cruz the annual mean temperature for 15 years was about 26.8° C. At the College of Agriculture, Los Baños, Laguna, for eight-year period, the figure was about 25.8° C. or 1.0° C. lower than that of Santa Cruz. The figure for Manila was 26.4° C. or 1.6° C. higher than the annual temperature at the College of Agriculture, Los Baños. The figures published by the Weather Bureau also show that there is a wider range of variation in temperature in Santa Cruz, Manila, and Batangas than at the College of Agriculture.

Rainfall, (Chart II).—The annual rainfall of the College of Agriculture, Los Baños, runs from 1600 to 3000 millimeters. The average for the eight-year period is about 2150 millimeters.

The data of rainfall for the eight-year period are of value in determining which parts of the year are best suited for different crops, taking into consideration the variety, the length of maturity, etc. The heavy rains begin in June and usually decline in quantity about the month of January, from which time

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[1] Experiment Station contribution No. 268.

[2] The weather observations at Los Baños were begun in 1913, under Dr. F. C. Gates, by Mr. Ocampo from the Bureau of Science. In 1916, under the direction of Dr. F. T. McLean, the observations here reported were begun by Mr. Victor Sulit, who, in 1917, was succeeded by Mr. V. Ravasa. The writer was put in charge in 1918 and continued the work until 1924. Prof. D. A. Herbert of the Department of Plant Physiology helped in preparing this paper and Prof. F. P. McWhorter, formerly of Departmentof Plant Pathology, assisted in preparing the charts. The weather observations are being continued.

[3] Coronas, Hose, Rev. The climate and weather of the Philippines, 1903 to 1918. Weather Bureau, Manila, 1920.

the rainfall is light. There was, however, hardly a month during this eight-year period in which there was no rain. The records show that there were always several centimeters of monthly precipitation even during the months from February to May of each year.

Judging from the monthly rainfall records, it appears that there are only two months in which the rainfall exceeded 500 millimeters. This was in August, 1918, when the precipitation reached over 1000 millimeters, and in November and July, 1923, when it was about 750 millimeters. In the other 66 months, the rainfall ran below 500 millimeters and was sometimes as low as 10 millimeters.

Wind velocity.—According to the records obtained, there is a range of wind velocity at the College of Agriculture of from 0.3 to 19.2 miles per hour. The figures are averages for a twenty-four-hour-period during stormy days. Strong winds usually occur during the months of June, July, and August and generally come from the northeasterly direction.[4]

Evaporation.—The records obtained at the College of Agriculture by the use of the Livingston atmometer show that the daily evaporation ranged from 1 to 60 cc. and the insolation from 0 to 30 cc. Most of the time the rate of evaporation and insolation go side by side, that is, when there was a high rate of evaporation there was also a correspondingly high rate of insolation, sometimes however, they were in the reverse order. The highest figures were obtained during the months of January, February, March, April, and May, and the lowest, during the months of July, August, September, and October of each year. The first group of months constitutes the dry season and the latter group the wet.

Humidity.—The weather records obtained at the College of Agriculture show that the daily average percentage of humidity of the air runs from 75 to 97. This is somewhat higher than that of the city of Manila which varies from 63 to 89 per cent.

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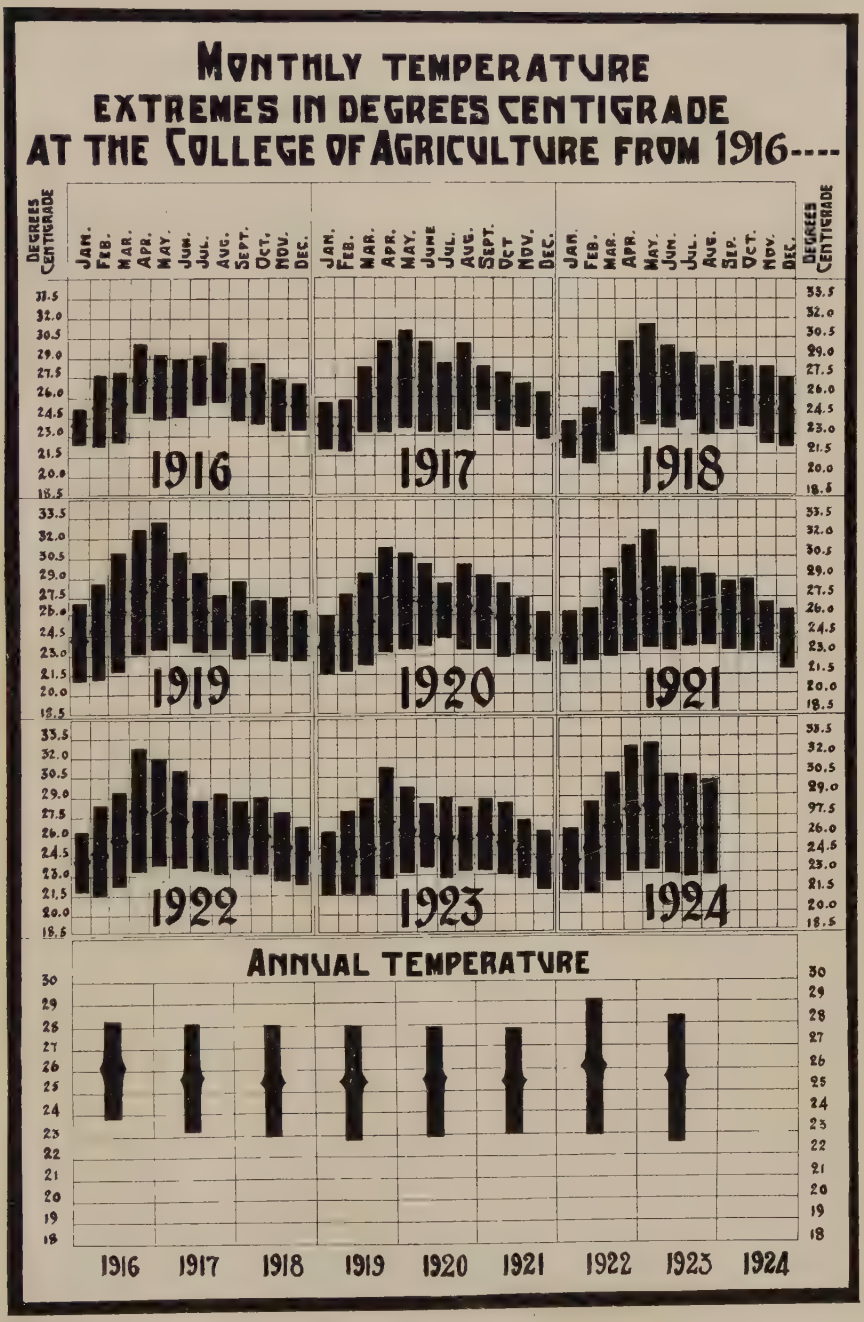
MONTHLY TEMPERATURE
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CHART I

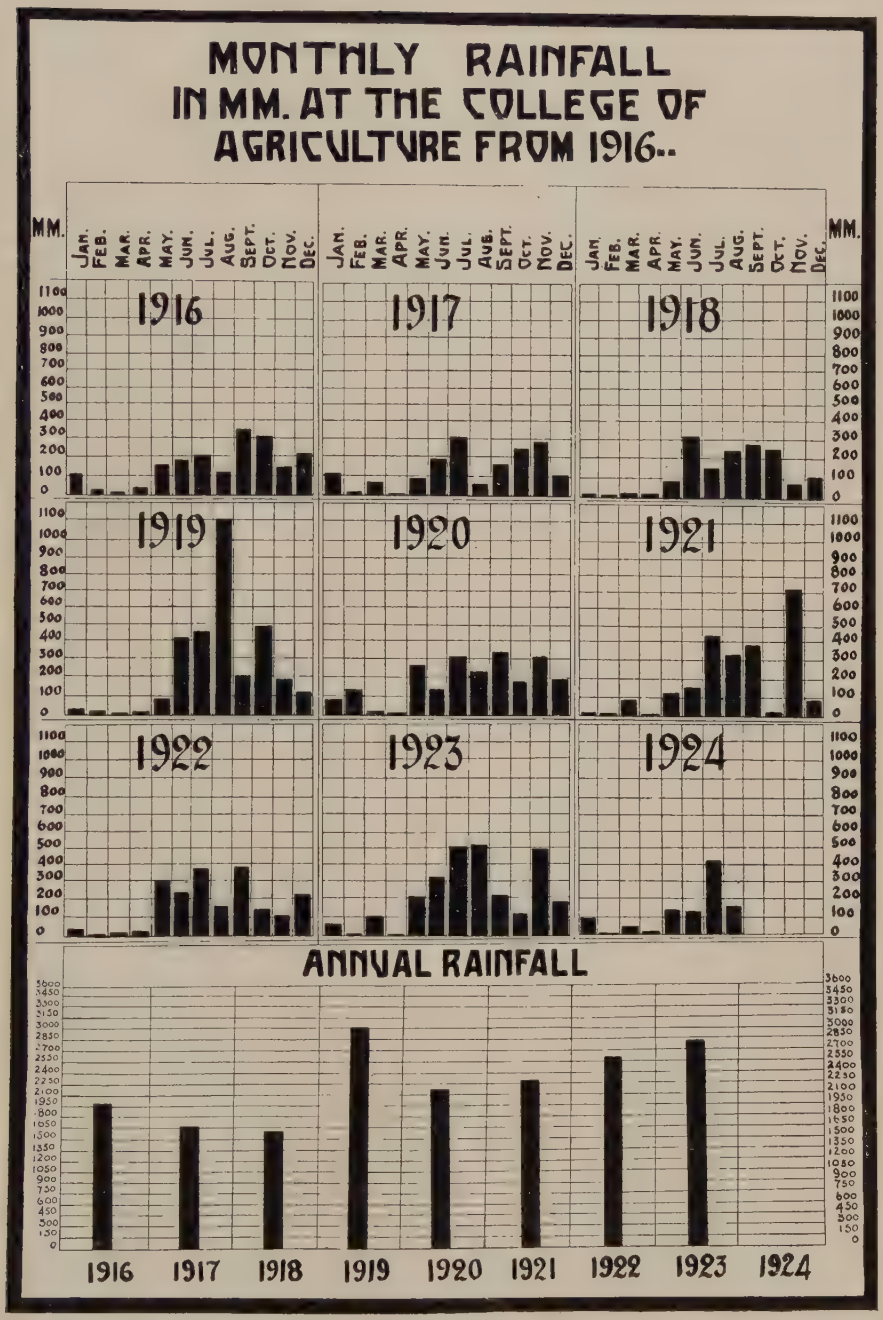
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CHART II

ABSTRACTS

The supplementary actions of some naturally occurring feeds for feeding chicks. JULIAN MAMARIL (*Thesis presented for graduation from the College of Agriculture, No. 197; Experiment Station contribution, No. 269*)[1].—The experiment was run in five lots, each containing 25 native chicks. A basal mixture consisting of one part by weight each of ground corn, ground rice, and rice bran was open to the chicks to feed for five minutes morning and evening. This ration was supplemented with a moist mash mixture which was fed for five minutes at intervals of two hours between the morning and evening rations. As the chicks grew older, the feeding of moist mash was gradually reduced to a noontime feeding. After six weeks the dry mash hopper was open for half an hour. A liberal supply of green grass in sod, drinking water, and a mixture of sand and fine broken shell was provided for the chicks.

The first feeding was 36 hours after hatching. From this age until 13 weeks old the chicks were weighed weekly.

"The cost of feeds was based on the current prices during the experiment, as follows: one kilogram each of corn, rice, copra meal, and rice bran, cost ₱0.092; ₱0.051; ₱0.495 respectively; milk cost ₱0.10 per 220 cc. and eggs ₱0.48 a dozen."

The chicks in the first lot, fed with the basal ration and a moist mash supplement containing one part by weight each of ground corn, ground rice, and rice bran moistened with either sour or sweet milk, were more vigorous, more active, and more uniform in weight than the chicks in the other four lots fed with other kinds of supplement. The mortality in this lot was the lowest.

The chicks in the second lot where the supplement used was one part by weight each, of hard boiled eggs chopped fine with the shell, ground corn, and rice bran were not quite as good as the chicks in the first lot. In this lot the cost of a bird up to 13 weeks was more than in the first lot.

The supplement used in the third lot was one part by weight each of copra meal, ground rice, and rice bran. This lot had the highest mortality.

The supplement used in the fourth lot was the same as in the first lot but without milk. White ants were given at noon for five minutes in addition to the supplement.

The supplement given in the fifth lot was one part by weight of ground rice, two parts of ground corn and three parts of rice bran.

The basal rations and the supplements given in the last three lots gave very poor results.

—*Abstract by Vicente M. Davis.*

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[1] Abstract prepared as part of required theme work in English 101, College of Agriculture.

The course of acidity changes during the growth period of wheat with special reference to stem-rust resistance. Annie May Hurd. (*Journal of Agricultural Research 27:* 725-735. *Fig. 1-5.* 1924.)—The author reports that the titrable acidity of the juice of the wheat plant decreases between the age of two and six weeks. During the same period the hydrogen-ion concentration of the juice does not decrease appreciably. At the pre-ripening period the titrable acidity becomes relatively low while the hydrogen-ion concentration is greatly increased. At the ripening period both the titrable acid and the hydrogen-ion concentration of the juice are relatively high. The increasing acid concentration is said to be correlated with the rate of drying but not with the head formation or kernel development.

The presence of high titrable acidity and hydrogen-ion concentration at maturity without having the intermediate period of low acidity is characteristic of stunted and slow-growing plants.

The resistance of wheat varieties to stem-rust is said not to be related to any stage development, to titrable-acid or hydrogen-ion concentration.

High acidity of the juice does not hinder stem-rust infection and low acidity does not predispose wheat plants to the disease.

—*Abstract by Macario A. Palo.*

EXCHANGE NOTES

A wise, skilled, and unselfish leadership can do more than anything else to rescue agriculture. The farmer needs leaders who will stay with him, who have the tact and the courage necessary for management, and who have the fidelity to refuse political preferment and business opportunity. There are such leaders. In the sacrifices they make to serve the farmer lies the greatest hope for his salvation.—*President Coolidge.*

A new process has been discovered whereby wood is ensured against dry-rot. This is done by impregnating it with a hot solution of sugar, which soaks into every cell, destroys all germs, and strengthens and hardens the substances of the timber. Treated in this way new wood does not require to lie for years to be "seasoned," as the sugar combines with sap and fills the pores to such a degree that after the wood is dried in a kiln it can no longer swell with damp, nor shrink through slow evaporation. This treatment is also said to ensure the wood against the attack of insects.—The *Journal* (The Madras Agricultural Students' Union).

"Hoppers," a film dealing with grasshopper control, particularly in the Western States, has just been completed by the department. This picture shows various methods of fighting grasshoppers, including the hopper catcher, the "balloon," the large flocks of turkeys, but particular stress is laid upon the poisoned-bait method of killing hoppers, and upon thorough plowing and harrowing of the fields for destroying the hopper eggs. Scenes illustrative of a community campaign, including a big "mixing bee," constitute the body of the picture. The Bureau of Entomology advocates such neighborhood campaigns as an effective means of checking grasshopper infestations in the spring and early summer.

Interesting features of this picture are scenes taken on "grasshoppers glacier," in Montana, where prehistoric hoppers are found frozen in the ice, and scenes taken in Africa showing great flights of grasshoppers such as are supposed to have figured in the Mosaic chronicle of the Plague of Locusts.—*Official Record* (U. S. Department of Agriculture).

It is well known that pen manure consists of two main components, animal excretions and litter. Of the former, urine is by far the more important. It not only contains compounds of immediate fertilizing value, but also furnishes nitrogen to the organisms that bring about the decomposition of the cellulose of the litter into brown humus-like substances. Much of our knowledge of the cellulose-decomposing organisms is due to the researches of Dr. Hutchinson and his co-workers at Rothamsted. These investigators have demonstrated that four main factors control the rapid multiplication of the more effective bacteria capable of decomposing cellulose. These factors are (1) an adequate supply of air, (2) an

adequate supply of moisture, (3) a sufficiency of inorganic, or simple organic, nitrogen compounds, and (4) the absence of certain toxins, such as reducing sugars and *higher* organic nitrogen compounds. In the absence of an adequate nitrogen supply, however, it is interesting to note that deficiencies may be made up by the activity of certain nitrogen-fixing bacteria which can thrive on the first-formed decomposition products of cellulose, provided these products include readily oxidizable substances. Thus the nitrogen-fixing bacteria may work in conjunction with the cellulose-decomposing organisms, and thereby augment the initial supply of suitable nitrogenous material in the medium.—*Tropical Agriculture.*

The British East Indies furnishes the largest portion of the rice imported into the United Kingdom although the United States figures as an important source of supply. Imports from the United States during the first five months of 1924 amounted to 22,315,000 pounds. Since 1922 the United States has been ranking second as a source of supply for the British rice market. American rice is considered to be the best on the market and is always in demand notwithstanding the fact that it is always more expensive than rice from other countries.

—*Crops and Markets* (U. S. Department of Agriculture).

Investigations made by the United States Bureau of Entomology and Bureau of Agricultural Economics have shown that the average annual loss to the Louisiana sugar-cane crop by moth-borer is approximately 19 per cent. In 1922 the damage was 17 per cent of the crop; in 1923 it amounted to as much as 23 per cent of the crop.—*Tropical Agriculture.*

The world's production of cacao in 1923 was 455,000 tons and the consumption 431,300 tons.

The worst prepared cacao now received in the London market comes principally from Haiti and Lagos (Nigeria).—*Tropical Agriculture.*

We cannot get on without growing corn and plenty of it. It is still our most important local crop, despite the great reduction in horse and mule transport. It is the most important grain crop of the world as it lends itself to far more uses than rice. The world's crop is between four and five billion bushels, 75 per cent of which is grown in the United States. Argentine produces 5 per cent, but is the largest exporter with around 30 million bags. It has become a most popular crop in South Africa where conditions of soil and climate suit it. The value of the crop there is stated to be £7,500,000.—The *Journal* (The Jamaica Agricultural Society).

COLLEGE AND ALUMNI NOTES

Mr. Herbert J. Rumsey from Dundas, N.S.W., Australia, a "between-boats" Philippines visitor, was a College caller recently. Mr. Rumsey who is a writer on agricultural subjects, an horticultural expert, with seed and plant merchandizing as his vocation, was on his way home from the very successful British Empire Exhibition held at Wembley, London, where he was one of the lecturers on agricultural topics. In discussing the many points of contact between Philippine agriculture and that of Australia, Mr. Rumsey was enthusiastic that closer relations should exist between the technical men of the two countries.

In the absence of Doctor Roxas, Dr. Francisco O. Santos, assistant professor of chemistry, has been designated as Acting Head of the Department of Chemistry.

Mr. Florencio A. Soliven has been promoted from assistant to instructor in chemistry; appointed to the position left vacant by the resignation of Mrs. Concepción Maramba-Henares.

At the November meeting of the Los Baños Biological Club the following papers were read:

"Pigs for Lechon," by B. M. Gonzalez and F. P. Lago.
(Paper read by Doctor Gonzales.)

"The Soft Rot of Pineapples in the Philippines and other Countries," by E. F. Roldan.

"Seedling Types of Rosal (*Gardenia florida* L.)," by José M. Capinpin.

At the December meeting papers on the following subjects were presented:

"Phytophora Blight of Citrus," by G. O. Ocfemia and E. F. Roldan.
(Paper read by Doctor Ocfemia.)

"On the Origin, Development, and Nature of the Stony Layer of the Coconut," by José B. Juliano.

"Protandrously Self-sterile Flowers of Hibiscus Rendered Fertile by Surgical Operation" by N. B. Mendiola.

The discussions on the papers were not perfunctory, dull, but animated, of interest even to the laymen present. The increasing attendance at these meetings as well as the papers presented, is evidence that the club is a live and growing organization.

The Index to Volume XII, PHILIPPINE AGRICULTURIST, is now in print. It was prepared by Miss Dorothy C. Hall of the English Department.

Members of the faculty and the seniors in the Animal Husbandry Department, and the class in meat inspection of the College of Veterinary Science, visited the Sisiman Quarantine Station on November 24. Sisiman is off the rocky coast of Mariveles on Manila Bay, and is the site of the Government slaughter house for imported Australian cattle.